



# RADIOLOGY

A MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY  
AND ALLIED SCIENCES

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NO 1

## THE DISTRIBUTION OF RADIATION WITHIN THE AVERAGE FEMALE PELVIS FOR DIFFERENT METHODS OF APPLYING RADIUM TO THE CERVIX<sup>1</sup>

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NO single plan of irradiation is suitable for the treatment of all patients with cervix cancer in each instance there must be some individualization of the case. However, it is always desirable to deliver radiation in a manner that will produce as small an amount of damage to normal tissues as is consistent with adequate treatment of the tumor-bearing region. Despite the fact that conditions vary with individuals, there are certain procedures that can be followed in the administration of roentgen rays, which will deliver a distribution of radiation suitable to the treatment of most patients. Data for these procedures were given in a previous paper (1), in which diagrams were published, showing the distribution of roentgen radiation within the average female pelvis for several arrangements of skin fields. Each plan studied was one which might be considered practicable in most radiologic departments, and was shown for target-skin distances of both 50 and 70 centimeters. Radiation was delivered by a 200 kv x-ray machine, with 0.5 mm Cu and 2.0 mm Al filter. An arrangement employing six fields, with a target-skin distance of 70 cm, was found to deliver the most satisfactory distribution of radiation.

For this particular technic, two fields were used on the anterior surface, two on the posterior, and one on each lateral aspect of the pelvis. All the irradiated skin areas were of the same size, 15 cm longitudinally and 10 cm transversely. It was found that fields of these dimensions would extend from the level of the iliac crests to the middle of the symphysis pubis on most patients. These bony landmarks can be used for marking out skin portals in any position in which the patient may be placed. Radiographic studies showed that both the promontory of the sacrum and the cervix were included within the direct beams.

On the anterior and posterior surfaces the fields were separated in the mid-line by a distance of 2 centimeters. Each beam was directed straight into the pelvis toward the underlying parametrium, and was not tilted toward the mid-pelvis. By this means both the bladder and rectum are spared doses in excess of the amount delivered to the cervix. Lateral beams do not contribute much radiation to structures at depths as great as the middle of the pelvis, but they do increase the total dose obtained in the parametrial regions, to such a degree that it actually becomes greater than the full amount of radiation delivered to the cervix. The distribution of radiation within the average pelvis with the chosen method is shown in Figure 1.

<sup>1</sup> Presented before the Radiological Society of North America at the Twenty-first Annual Meeting, in Detroit Dec 2-6 1935.

This distribution of roentgen radiation is suitable for the treatment of cervix cancer, not only because of the protection afforded

work for this purpose. The distribution of radiation obtained from several methods of applying radium will be studied. Each ap

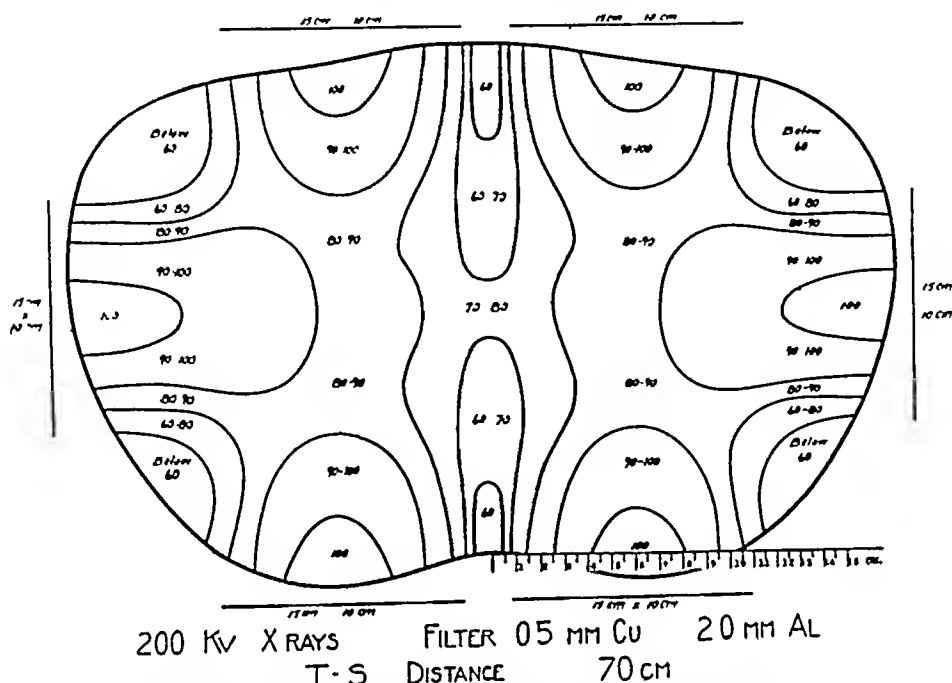


Fig 1 The distribution of roentgen radiation within the average female pelvis for six fields measuring 15 X 10 cm each and arranged in the manner shown

the bladder and rectum, but also because the parametrial regions receive a greater dose than the cervix. Radium applied to the cervix will control the disease in the primary lesion in most instances, but will not deliver a lethal dose to a tumor located at a distance greater than three or four centimeters from the cervical canal. External irradiation must be relied upon to treat adequately parametrial and outlying tumor-bearing regions. It is unlikely that patients would tolerate the amount of roentgen radiation required to deliver the same dose to the parametrial regions as is obtained throughout most of the primary lesion from radium applied to the cervix. However, when both radium and x-rays are employed, one supplements the other so that the total volume of tissue receiving a lethal dose is increased. Since no detailed consideration was given to radium applied to the cervix in the previous publication, it was considered desirable to extend the

plection will be shown within a diagram of the uterus and bony pelvis. The one found to be the most desirable will be illustrated in combination with x-rays delivered through six fields with a target-skin distance of 70 centimeters.

The outline of the bony pelvis used in each diagram has been determined from the measurements given for the average female pelvis by Williams (2), and Davis (3). Since most patients with carcinoma of the cervix have borne children, the size of the uterus (8.0 X 5.0 X 3.5 cm) was determined from data given for multiparous uteri by Williams and Davis.

The various diagrams will be compared to determine the differences in the distribution of radiation obtained from the various methods of applying radium to the cervix. The measurements of the bony pelvis do not vary sufficiently to cause any problem in representing the average patient. Neither are variations in the size of the

uterus of great importance, because the dimensions used in the diagrams represent an average multiparous uterus not complicated by special conditions such as myomas, or other pelvic diseases. In practice, the position of the uterus, and the gross character of the cervical lesion will vary considerably in various patients. However, for the sake of comparison, certain conditions must be assumed to be constant. It will readily be seen that the data here given can be applied to other cases, when the position of the uterus and size of the lesion are known. The uterus has been shown as lying in a plane almost parallel to the patient's length, because it will usually assume a position of moderate retroflexion when the patient is lying in bed, with radium placed in the canal and with the vagina packed. The primary lesion has been represented as one in which the cervix is not destroyed, and measures 3 cm in diameter. The fornices have been assumed to be free from disease, so that radium could be placed lateral to the cervix.

In comparing the diagrams, it is not only necessary that they be constructed upon comparable anatomical conditions, but also that approximately equal total doses of radium must be used in order to illustrate any improvement in the distribution of radiation obtained from one particular method of application over another. The distribution of radiation obtained from an intra-uterine tandem for a dose of 3,000 mg-hr will be considered first. In studying methods for improving the distribution of radium radiation, the tandem will be shown for a dose of 5,000 mg-hr, and in combination with other sources of radiation (such as needle, bomb, plaque, and colpostat) for total doses of from 4,500 to 5,000 milligram-hours.

Some of the methods illustrated for applying radium to the cervix may be similar to the methods followed by certain individuals, but found to differ in the doses delivered by the various sources of radiation. Techniques advocated by other authors cannot always be followed accurately in the diagrams, because these have been pre-

pared to compare the distribution of radiation obtained from various methods of applying a given amount of radium to the cervix. Data upon the distribution of radiation obtained from particular methods and specified doses have been published by Selmitz (4), Healy (5, 6), Mallet and Coliez (7), and others. It is intended that by comparison of the diagrams presented here, the method most suitable in the average case can be determined. Obviously no particular application can be advocated as a routine method of treatment for all patients with cervix cancer, a procedure adaptable to one may be impractical for another.

It has already been stated that some diagrams will demonstrate the distribution of radiation obtained from both radium and x-rays. In such instances it is necessary to employ some unit that can be used for expressing the combined amount of radiation delivered by the two sources. If, in addition to x-rays, several sources of radium radiation are used for varying doses in the same patient, it is impractical to express the combined amounts of radiation delivered to a given point at a particular depth in terms of percentages of the surface dose. The so-called threshold erythema dose serves very well for a unit. This has been defined by Qumby (8) as representing an amount of radiation which, given at a single exposure, will produce a visible reddening or bronzing of the skin in 80 per cent of the individuals within four weeks after receiving the dose, and no visible reaction in the remaining 20 per cent. While the definition originally related to external irradiation by x-rays or radium, it has been extended by Martin and Qumby (9) to interpret doses from interstitial sources of radium, such as seeds, needles, tandems, etc.<sup>2</sup>

<sup>2</sup> The threshold erythema dose is approximately 525 roentgens (air) for 200 kv x-rays, with 0.5 mm Cu filter and a skin field measuring 10 × 10 cm. For other fields it may be determined in accordance with data on the effect of size of field on tissue dose (Failla, G., and Qumby, E. H. *The Economics of Dosimetry in Radiotherapy*. *Am Jour Roentgenol and Rad Ther*, 1923, 10: 944-967). The threshold erythema dose for radium is about 225 mg-hr for a tube 2 cm long at a distance of one centimeter. Data are given for other sources or distances in a paper by Qumby (14).

It is impractical to show differences of a single threshold erythema dose on the diagrams, because of the great intensity near the source of the radium radiation, and the rapid decrease in the percentage depth dose a few centimeters away. In any case the estimation of tissue dose can be only approximate. Since it is necessary to demonstrate the distribution of radiation by showing differences of several erythemas, it is desirable to group the threshold erythemas according to a greater or lesser amount than the suspected lethal dose for cervix cancer. Data presented in collaboration with Healy (10), and Stewart (11), indicate that in most instances a minimum dose of from six to eight threshold erythemas, distributed throughout the primary lesion, is required to destroy completely the disease in the cervix and to prevent its recurrence. In the diagrams presented here the minimum dose indicated is from one to four threshold erythemas. It is doubtful that this amount of radiation would be very effective in destroying the disease. The distribution of from four to seven threshold erythema doses is shown, which represents an amount of radiation that would be expected to produce marked changes in the tumor. The volume of tissue that receives from seven to fifteen threshold erythema doses is also indicated in each diagram, within this region the disease should surely be destroyed. Finally, the volume of tissue that receives doses in excess of 15 threshold erythemas is shown. Sloughing and necrosis may occur in these regions.

For the preparation of the diagrams it was first necessary to make several charts showing isodose curves about given sources of radium radiation. Each chart was for a particular source of radiation, and showed the distribution of threshold erythemas for a specified dose. The isodose curves were usually drawn in a plane parallel to the length of the capsule, tube, needle, etc. However, in some instances it was necessary to show also the distribution of threshold erythema doses in a plane transverse to the middle or around the end of the

source of radiation. Data for the various isodose charts were taken from several publications. Qumby (12, 13, 14), Qumby and Stewart (15), Martin and Qumby (9), and Laurence (16). Data for the bomb shown in one diagram were obtained from publications by Healy (5, 6). In every method studied, the radium filter was considered to be equivalent to 2 mm brass.

Diagrams shown here, illustrating the distribution of threshold erythema doses for several methods of applying radium to the cervix, were prepared by placing the proper isodose chart in the correct position for treatment, under an outline of the uterus and bony pelvis drawn on transparent paper. The contribution from each source of radiation was noted at various points within the pelvis, and the sum of all these calculated for each point. Lines drawn through points receiving the same total radiation divide the pelvis into regions receiving specified doses. Such lines were drawn for total amounts of radiation corresponding to one, four, seven, and 15 threshold erythema doses. For combining radium and x-rays, data were obtained from the publication (1) already referred to. The dose of roentgen radiation delivered to each skin field will be discussed when diagrams showing the combination of the two types of radiation are considered.

For comparing the relative value of the different methods of applying radium to the cervix, several factors are to be considered. The amount of radiation delivered throughout the cervix must be sufficient to control the disease in the primary lesion. However, too great a dose may produce a persistent radiation ulcer, which is apt to give rise to various complications. The dose delivered to the parametrial regions should also be noted, as well as the amount of radiation reaching the bladder and rectum. Therefore, in comparing the diagrams illustrating the various methods, it is desirable to note the volume of tissue receiving doses in each instance, considering later a g

## DISTRIBUTION OF RADIUM RADIATION

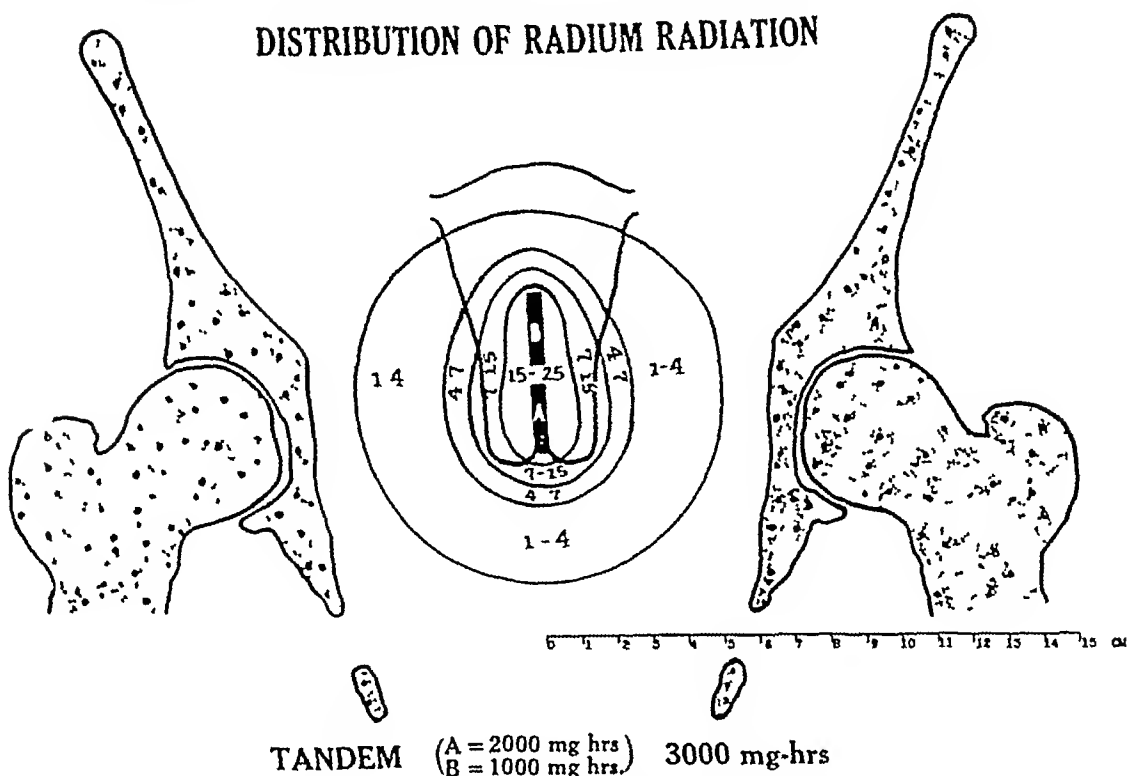


Fig 2 The distribution of radium radiation within the average female pelvis for an intra-uterine tandem consisting of two capsules, for a dose of 3,000 mg -hrs

cated by the isodose curves. For amounts of radiation distributed throughout the cervix, measurements will be made in a transverse plane extending laterally from a point corresponding to the center of the lower capsule in the tandem. This plane will be, therefore, about one centimeter above the external os. In considering parametrial doses, measurements will be made in a transverse plane extending laterally from a point corresponding to the middle of the tandem, which will be about 2.2 cm above the external os. By such a comparison it will be possible to demonstrate the value of certain methods in delivering greater amounts of radiation to the parametrial regions, without over-irradiating the primary lesion.

Not only must the distribution of radiation throughout the tumor-bearing region be considered, but attention must be given also to the dose delivered to the bladder and rectum. In many instances these regions are not infiltrated by the disease, and must be protected from excessive doses. A

method of applying radium that will minimize the quantity delivered to these structures, and yet deliver a suitable dose to regions that harbor disease would be the most desirable.

#### INTRA-UTERINE TANDEM WITHOUT OTHER SOURCES OF RADIUM RADIATION

In most clinics the tandem used for the treatment of cervix cancer consists of two capsules. A greater amount of radium is usually contained in the cervical end of the tandem than in the portion extending into the uterine cavity. The minimum dose employed is probably about three thousand milligram-hours. In Figure 2 is shown the distribution of threshold erythema doses for 3,000 mg-hr delivered by a tandem composed of two capsules, the lower one of which is twice the strength of the upper. Each capsule measures 2 cm. in length, and 4 mm. in diameter.

For a dose of 3,000 mg-hr from the tandem described above, 2,000 mg-hr would be delivered by the lower capsule, labeled

"A," and 1,000 mg-hr by the upper one, labeled "B." Since two-thirds of the total dose is delivered by the lower capsule, the isodose curves near the source of radiation include a greater volume about the cervical portion of the tandem, than they do around the upper end. Isodose curves indicating doses delivered to points farther away from the tandem do not show such a marked effect from the unequal distribution of radium.

Immediately about the tandem is shown a dose of from 15 to 25 threshold erythemas. This amount of radiation may be expected to produce necrosis and sloughing, and extends laterally from the center of the lower capsule for a distance of about one centimeter. The distribution of from seven to fifteen threshold erythema doses, which may be considered a lethal amount of radiation in most instances, is over a volume of tissue that includes all the cervix, and extends into the parametrial regions for a distance of about two centimeters, lateral from the middle of the tandem. From four to seven threshold erythema doses are delivered into the parametrial regions for a distance of only 2.5 cm from the middle of the tandem. It is unlikely that less than four threshold erythemas would produce any permanent damage to cervix cancer. One threshold erythema dose is delivered into the parametrial regions 5 cm from the middle of the tandem.

Since the sources of radiation are arranged in tandem formation, the distribution of threshold erythema doses in the anteroposterior diameter would be the same as has been shown for the transverse plane, if the capsules of radium remained in a straight line. Reasons have already been given for assuming in each diagram that the uterus was in a position of moderate retroflexion, lying almost parallel to the patient's length. It may be estimated, therefore, that both the bladder and rectum receive from one to five threshold erythema doses. If there were an acute flexion of the corpus in either a forward or backward direction, there might have been some increase in the bladder or rectal dose

directly adjacent to the uterus. In either event, however, the amount of radiation delivered throughout most of the bladder and rectal regions would remain from one to five threshold erythema doses.

As has been stated, it is necessary that each of the various diagrams illustrate the same anatomical conditions, so that a comparison of the relative value of the different methods can be made. In practice, however, there are many variations in the gross character of the lesion in individual cases of cervix cancer. The anatomical conditions illustrated in the diagrams represent a uterus of average size, in which the gross anatomy has not been distorted greatly by the tumor. Such conditions would usually exist only in patients with early disease. In some instances, especially in advanced carcinoma, the cervix might be increased in size, or it might be destroyed. Enlargement of the cervix may be diffuse, or involve only a portion of the organ. Since the size of the isodose regions remains the same in every instance, the distribution of radiation obtained throughout a cervix of greater dimensions could be determined by drawing in the actual size of the particular lesion under consideration. For instance, if disease enlarged the cervix to a diameter of 3.5 cm, it would still receive a minimum distribution of from seven to fifteen threshold erythema doses. This would probably be sufficient to control the disease in the primary lesion in most instances. However, if the diameter were greater, some portions of the cervix would receive only from four to seven threshold erythema doses.

In a number of clinics the tandem has been used for doses in excess of 3,000 mg-hr in an attempt to deliver a greater amount of radiation to the adjacent parametrial regions. Newell (17) and Crossen (18) have reported the use of a tandem of 100 mg for 5,000 milligram-hours. The published statistics indicate that the percentage of five-year survivals will be increased over that obtained for lesser doses.

In Figure 3 is shown the distribution of threshold erythema doses for 5,000 mg-hr delivered by a tandem identical to the one

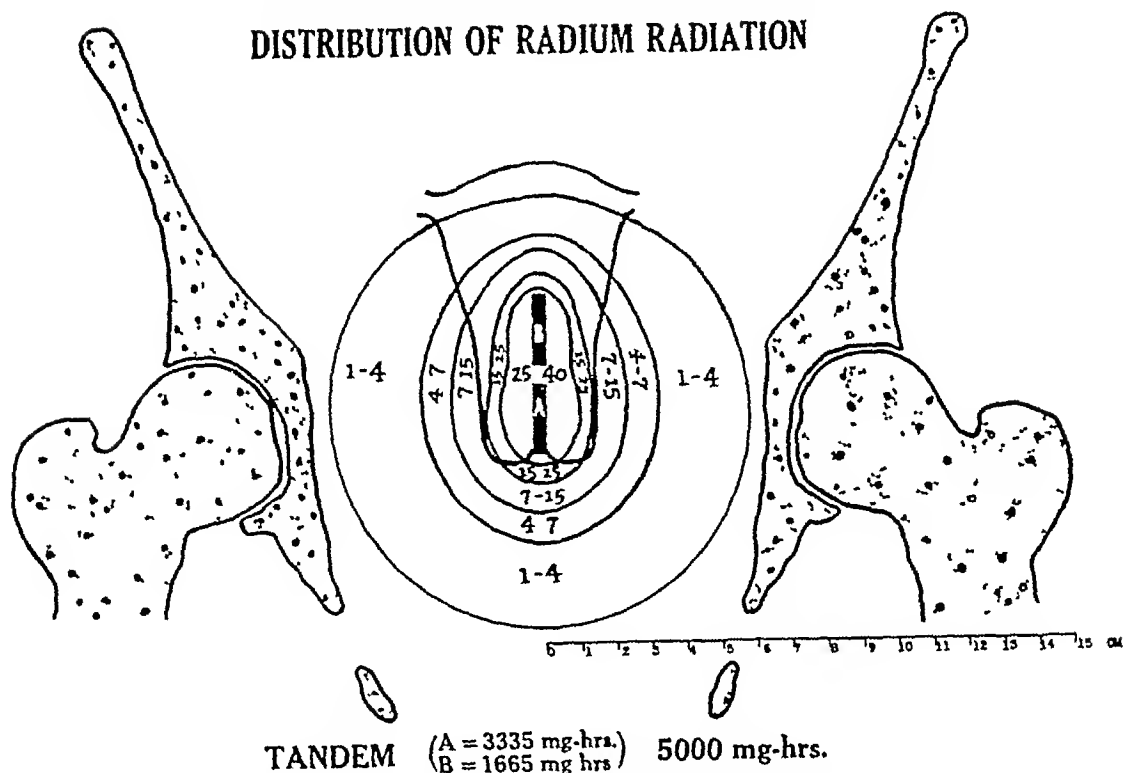


Fig 3 The distribution of radium radiation within the average female pelvis for an intra-uterine tandem consisting of two capsules for a dose of 5,000 mg -hrs

discussed above. Immediately about the tandem is recorded a dose of from 25 to 40 threshold erythemas. There is a minimum distribution of from fifteen to twenty-five threshold erythema doses throughout the cervix for a distance of 1.5 cm lateral to the center of the lower capsule. In the preceding diagram for 3,000 mg -hr, a distribution of from seven to fifteen threshold erythema doses was shown to extend into the parametrial regions for a distance of about two centimeters lateral to the middle of the tandem. For 5,000 mg -hr the same dose reaches a distance of only 2.5 cm from the middle of the tandem. From four to seven threshold erythema doses are delivered about 3.5 cm away, and one threshold erythema is delivered 6 cm out into the parametrial regions.

The amount of radiation reaching the bladder and rectum may be estimated in the same manner employed before. Upon this basis it may be said that these regions receive from one to eight threshold erythema doses.

Percentage depth doses for interstitial sources of radiation are lower than those obtained from sources in which some distance intervenes between the radium and the surface to which it is applied. Therefore, if the dose delivered by a tandem is increased considerably, there will be only a slight improvement in the amount of radiation reaching points two or three centimeters away. This can be noted by comparing the two diagrams just mentioned. The use of 5,000 mg -hr instead of 3,000 mg -hr represents an increase of 66 per cent in the dose delivered by the tandem. There is only a 25 per cent increase in the distance lateral to the middle of the tandem that the supposed lethal dose (from seven to fifteen threshold erythema doses) is delivered into the parametrial regions. For such an increase in the dose delivered by the tandem there is a greater amount of tissue damage at the site of the application of radium. The distance that a dose expected to produce necrosis and sloughing (above 15 threshold erythema doses) ex-



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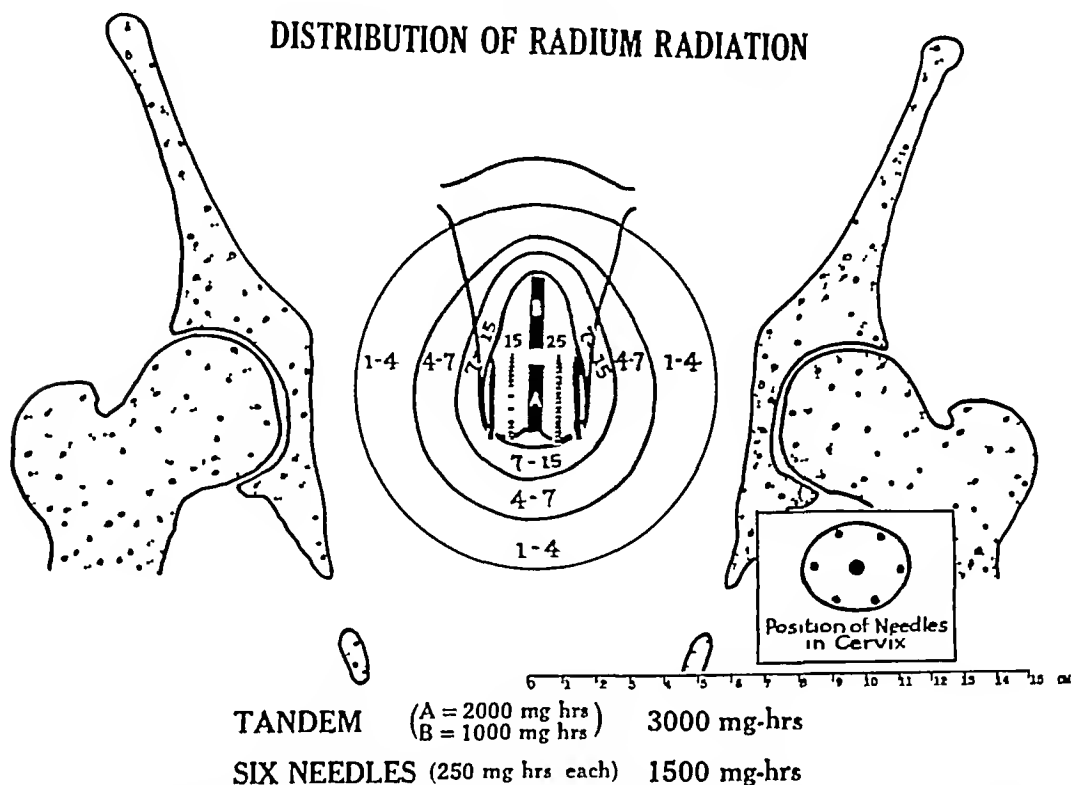


Fig 4 The distribution of radium radiation within the average female pelvis for an intra uterine tandem in combination with needles inserted into the cervix

tends lateral to the center of the lower capsule is increased 50 per cent

For both the doses mentioned, a volume of tissue surrounding the tandem is over-irradiated. It would be desirable to obtain the improvement in the parametrial dose, without increasing this volume. There would also be an advantage in preventing any tissue from receiving a dose in excess of 25 threshold erythemas. Furthermore, it might be impractical to deliver large doses of roentgen radiation to patients in whom there was already considerable destruction of tissue by radium. External irradiation is of great importance in the attempt to treat adequately disease located beyond the zone of effect of radium applied to the cervix. It should be mentioned that the distribution of threshold erythema doses shown for tandems placed in the uterine canal does not apply to those instances in which radium has been packed into a

cratered lesion, or against the cervix, when the canal cannot be located

#### INTRA-UTERINE TANDEM COMBINED WITH OTHER SOURCES OF INTERSTITIAL RADIATION

Some authors have reported the use of an intra-uterine tandem in combination with other sources of interstitial radiation. Ward and Sackett (19) have published the description of a technic, in which radium needles are inserted in the periphery of the cervix at the junction with the vaginal fornices. If the entire cervix is involved with disease, needles may be inserted all the way around the cervix.

In Figure 4 is shown the distribution of threshold erythema doses for an intra-uterine tandem in combination with radium needles. A dose of 3,000 mg-hr is delivered by the tandem. Six needles of equal strength, inserted about the periphery of the cervix, deliver a combined dose of 1,500

milligram-hours The total dose from all sources of radiation shown in the diagram is 4,500 milligram-hours For the specified conditions the needles will contribute a minimum dose of about four threshold erythemas throughout the cervix They will also deliver from one to four threshold erythema doses to the adjacent parametrial regions From both the tandem and the needles from 15 to 25 threshold erythema doses are delivered throughout the cervix for a distance of 1.5 cm lateral to the center of the lower capsule A dose of from seven to fifteen threshold erythemas is delivered into the parametrial regions for a distance of a little more than 2 cm lateral to the middle of the tandem From four to seven threshold erythema doses reach a point about 3.5 cm out into the parametrial regions, and one threshold erythema is delivered a little more than 5 cm away from the middle of the tandem

The distribution of radiation anterior and posterior to the uterus will be essentially the same as has been shown for the lateral plane Both the bladder and rectum may be expected to receive from one to seven threshold erythema doses If needles are inserted in the periphery of the cervix only at the junction with the lateral vaginal fornices, the bladder and rectal dose near the uterus will be diminished However, if the combined amount of radiation delivered by the various needles is decreased, a lesser dose will be delivered to the primary lesion and the parametrial regions

The insertion of needles into the cervix influences the distribution of radiation throughout the primary lesion more than it does the parametrial dose For the specified doses from the sources of radiation shown in the diagram, the minimum amount of radiation delivered to the cervix and vaginal fornices is practically the same as was obtained from the tandem alone for 5,000 milligram-hours Doses above 25 threshold erythemas are avoided The needles do contribute some radiation to the parametrial regions, but the improvement over the tandem alone for 3,000 mg-hr is

not quite as great as was noted for 5,000 mg-hr from the tandem For patients in whom there is a bulky cervical lesion, needles may be used to increase the dose in this volume of tissue, instead of delivering excessive doses from the intra-uterine tandem However, the amount of radiation delivered to the bladder and rectum will be about the same, whether the tandem is used for 5,000 mg-hr, or needles are employed in the manner shown In some individuals the bladder may receive a slightly greater dose than the rectum At the Memorial Hospital, Dean (20) noted that bladder injuries following irradiation for cervix cancer are more apt to occur in patients treated with interstitial sources, than in those who are given an intra-uterine tandem for a dose of about 3,000 mg-hr in combination with an intravaginal applicator The dose delivered to the primary lesion can be increased by means of intravaginal applicators in combination with an intra-uterine tandem In many instances this procedure may be more practical than the use of interstitial sources

#### INTRA-UTERINE TANDEM COMBINED WITH INTRAVAGINAL APPLICATORS CONTAINING RADIUM

The gross character of the primary lesion in cervix cancer presents such a variety of forms that no particular intravaginal applicator is suitable for the treatment of all patients Several types of applicators have been described by Healy (5, 6), and Heyman (21), for placing radium against the surface of the various types of cervical lesions The one most frequently employed by Healy has been the so-called "bomb," the shape of which may be compared to an egg, except that the irradiating surface is flat Radon is contained inside the applicator so that a radium-skin distance of about 1.2 cm is provided Lead walls of the bomb reduce considerably the amount of radiation reaching surrounding tissues, except in the direction of the primary beam used for treatment, which is 1.5 cm in diameter at the surface

The bomb can be applied in any of three

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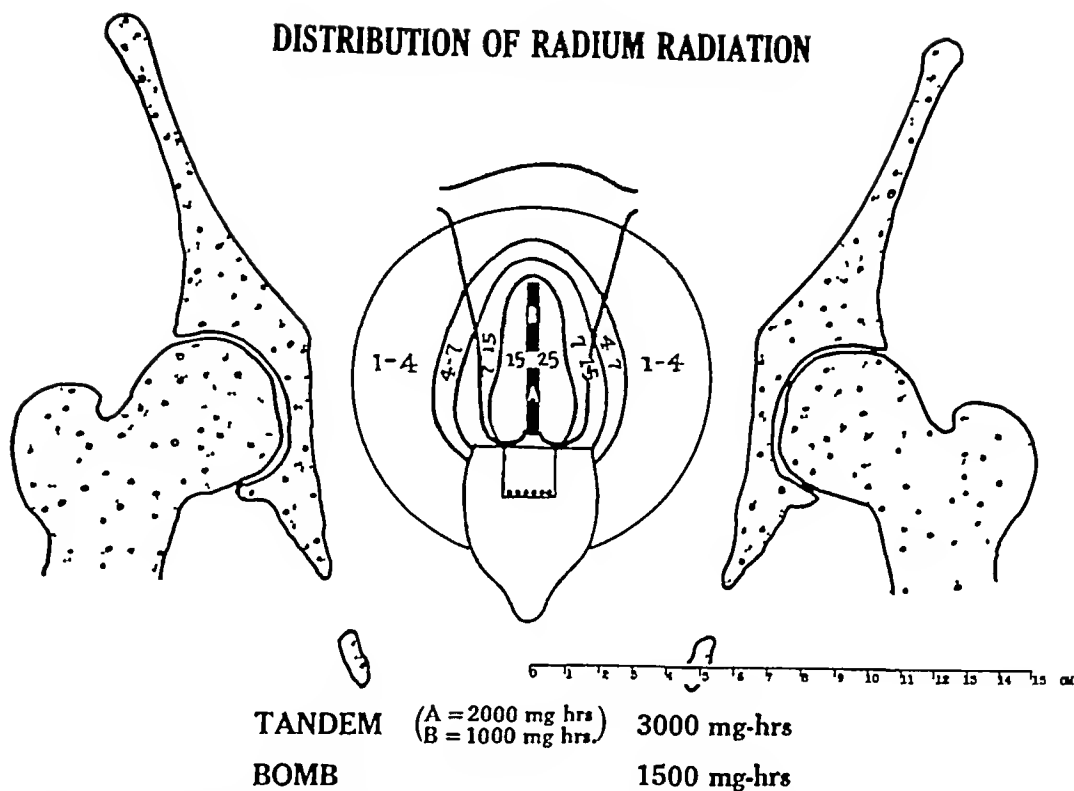


Fig 5 The distribution of radium radiation within the average female pelvis for an intra uterine tandem in combination with a bomb placed against the cervix

positions, so that the beam is directed toward the cervix, or into the right or left lateral fornix. Doses of 1,000 mc-hr to 1,500 mc-hr are usually given for each application. It was found that the use of the bomb in all three positions, in combination with an intra-uterine tandem for 3,000 mg-hr, delivered too great an amount of radiation in most instances. Because of the severe reactions, during the past several years Healy has generally used the bomb only against the cervix.

In comparing methods for applying radium to the cervix, it is impossible to consider all the various conditions with which one is confronted in the treatment of cervix cancer. Neither is it practical to discuss the various procedures that may be followed by a particular individual to obtain the most satisfactory distribution of radiation for each patient. Of all intra-vaginal applicators the bomb is perhaps the most easily used. The difficulties encoun-

tered in placing radium against the cervix may be so great in some patients that only the bomb can be introduced into the vagina. In such instances it is usually impossible to place the applicator in any position other than straight against the cervix.

In Figure 5 is shown the distribution of threshold erythema doses for the bomb placed against the cervix for a dose of 1,500 mg-hr, in combination with an intra-uterine tandem for 3,000 milligram-hours. It has been shown in this position so that a comparison can be made with other procedures in which radiation is delivered into the lateral fornices.

Most of the radiation delivered by the bomb, in the position shown, is contributed to a volume of tissue that receives a greater dose from the tandem. For the specified conditions, the bomb delivers from one to three threshold erythema doses to this region. The change produced in the isodose curve surrounding the tandem is not as

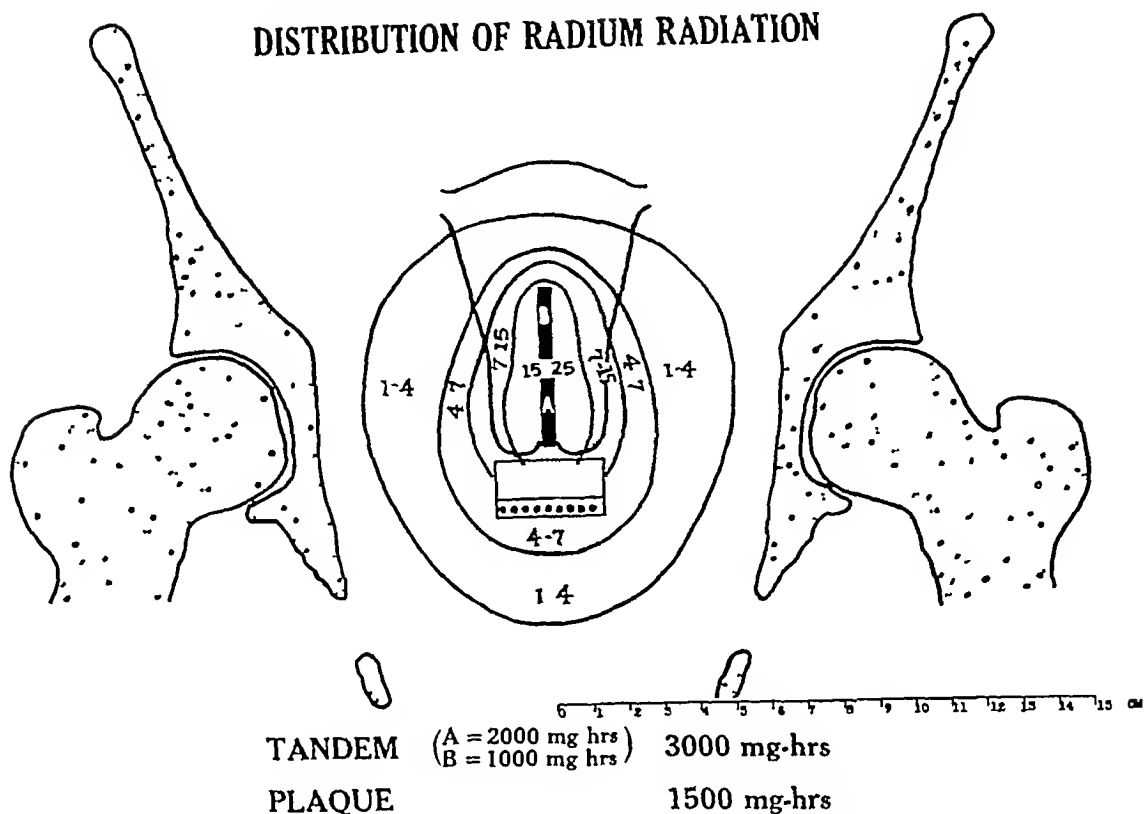


Fig 6 The distribution of radium radiation within the average female pelvis for an intra-uterine tandem in combination with a plaque placed against the cervix

marked as for the curves indicating lesser doses. The volume of tissue in the primary lesion and vaginal fornices, throughout which the supposed lethal dose is delivered by the bomb and tandem combined (from seven to fifteen threshold erythemas), is practically the same as that noted in the diagram illustrating the use of needles. The parametrial dose shows only a slight improvement over that obtained from the tandem alone for 3,000 milligram-hours. The bladder and rectal regions may be estimated to receive from one to six threshold erythema doses.

Another intravaginal applicator that is employed frequently is the so-called plaque. These applicators may be of various sizes, and, like the bomb, can be used for delivering radiation to the cervix, or vaginal fornices. If a plaque is placed directly against the lesion, the distance between the radium and the surface to which it is applied will be

only a few millimeters. In such instances the percentage depth dose will be lower than for the bomb. The percentage depth dose can be increased by lengthening the radium-skin distance with rubber, cork, or some other organic material, placed on the irradiating surface.

In Figure 6 is shown the distribution of threshold erythema doses for an intra-vaginal plaque, measuring  $3 \times 2$  cm, in combination with an intra-uterine tandem. The plaque is shown directly against the cervix for a dose of 1,500 mg-hr, with a radium-skin distance of one centimeter. The tandem dose is 3,000 mg-hr, as usual.

As was noted for the bomb, the plaque delivers from one to three threshold erythema doses to the cervix, and adjacent tissues. The distribution of radiation throughout the parametrial regions is practically the same as that shown for the bomb. The dose delivered throughout the

## DISTRIBUTION OF RADIUM RADIATION

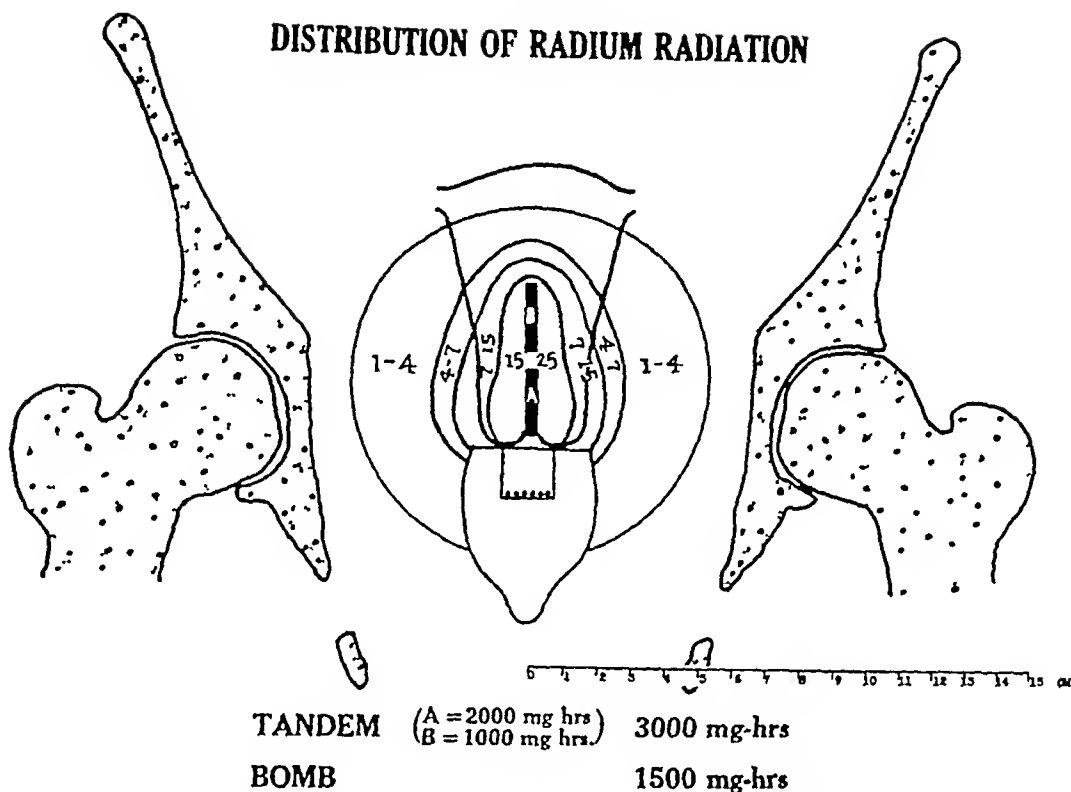


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Most of the radiation delivered by the bomb, in the position shown, is contributed to a volume of tissue that receives a greater dose from the tandem. For the specified conditions, the bomb delivers from one to three threshold erythema doses to this region. The change produced in the isodose curve surrounding the tandem is not as

tion is influenced more by this distance, than it is by the position in which the capsules are placed. That is, for identical doses and distances, the distribution of radiation will be essentially the same, whether the capsules in the fornices are parallel, or at right-angles to the tandem.

Since the radium located lateral to the cervix is held in a container of organic material, the capsule does not come in direct contact with the mucosal surface. For such an applicator, therefore, a radium-skin distance is provided that is equivalent to the thickness of the wall of the container. This may be from 0.5 to one centimeter. It should be mentioned that the colpostat is an applicator that is best suited for patients with a fairly roomy vagina, in whom the fornices are not obliterated by the disease. If the diameter of the vaginal tube is diminished, or if the fornices are infiltrated so that they cannot be expanded, it may be very difficult to place a colpostat in the correct position.

In Figure 7 is shown the distribution of radiation for a colpostat in combination with an intra-uterine tandem. The capsules located in the fornices lie in a plane parallel to the anteroposterior diameter of the patient, which is at right-angles to the intra-uterine tandem. The distance between the center of each capsule in the fornix, and the middle of the cervical portion of the tandem, is 2.5 centimeters. The two sources of radium lateral to the cervix are, therefore, 5 cm apart. If a radium-skin distance of 0.5 cm is used, the vagina will have to be distended to a transverse diameter of 6 centimeters. This can probably be accomplished in most patients. Each capsule in the intravaginal applicator is shown for a dose of 1,000 milligram-hours. The intra-uterine tandem is illustrated for 3,000 milligram-hours. The total dose from all sources of radiation included in the diagram is 5,000 milligram-hours.

The entire cervix receives from 15 to 25 threshold erythema doses. This amount of radiation extends lateral to the center of the lower capsule of the tandem for a dis-

tance of a little more than three centimeters. However, the region lateral to the cervix, throughout which such a large dose is distributed, is confined chiefly to the volume occupied by the colpostat itself. From seven to fifteen threshold erythemas are delivered into the parametrial regions for a distance of almost 3.5 cm lateral to the middle of the tandem. From four to seven threshold erythema doses are delivered about one centimeter further, and one threshold erythema reaches the pelvic wall, which is 6.5 cm away.

The distribution of radiation anterior and posterior to the uterus is quite different from that which has been shown in the transverse plane. From a diagram not included here, it may be estimated that the bladder and rectal regions receive from one to seven threshold erythema doses.

The diagram shown for the colpostat illustrates the importance of delivering radiation through the vaginal fornices, whenever anatomical conditions permit such a treatment. By this means the parametrial dose can be increased materially, without delivering excessive doses from any particular source. If the sources of radiation in the lateral fornices are located at a considerable distance from the intra-uterine tandem, they do not contribute greatly to the dose delivered to the bladder and rectum. A method which would deliver a beam of radiation toward the parametrial regions (such as the intravaginal bomb directed toward the fornices), would afford even greater protection to the bladder and rectum.

#### DISCUSSION

No single method that has been illustrated for applying radium to the cervix is suitable for the treatment of all patients. Neither are the doses specified in any instance to be advocated as a routine for a particular technic. Every case of cervix cancer must be individualized, and the treatment planned accordingly. The data given for each of the methods may be applied to any given patient by drawing in the proper outline of the lesion and uterus.

## DISTRIBUTION OF RADIUM RADIATION

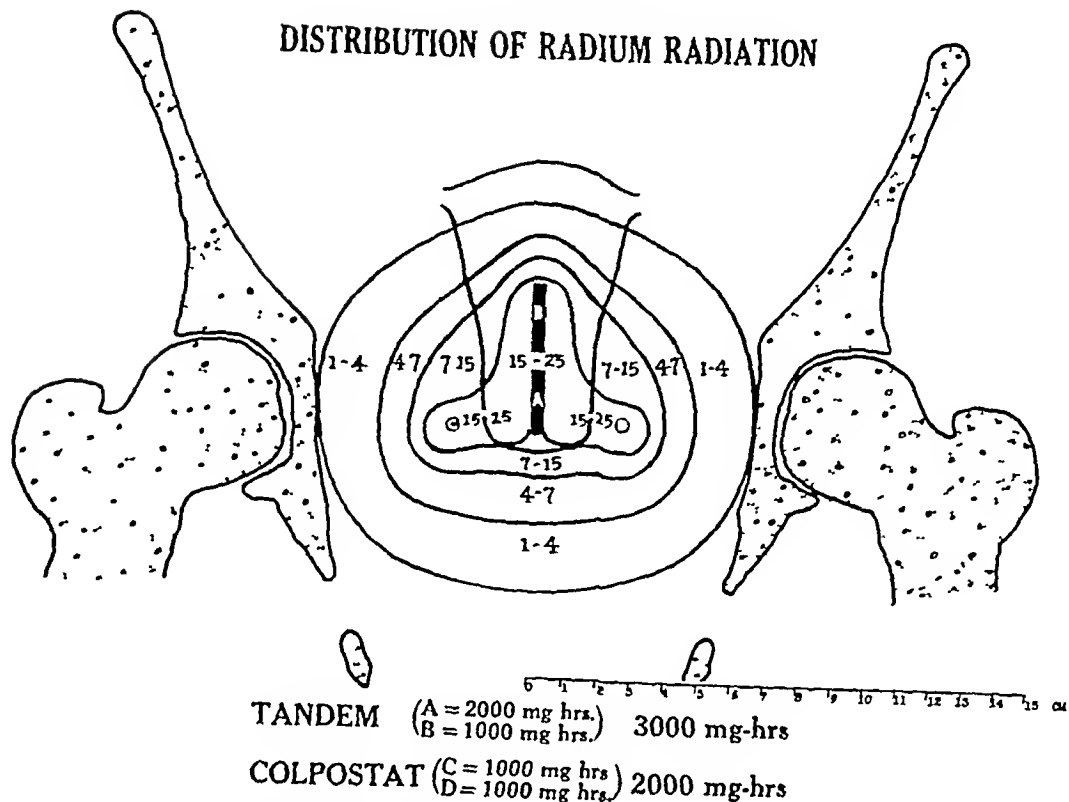


Fig 7 The distribution of radium radiation within the average female pelvis for an intra uterine tandem in combination with sources of radiation located in the lateral vaginal fornices by means of a colpostat

primary lesion and adjacent vaginal fornices is also about the same, except that the isodose curves indicating less than seven threshold erythemas include a greater volume of tissue near the level of the plaque. This is due to the fact that the wall thickness of the average plaque is only a few millimeters. Radiation is, therefore, delivered in all directions. For the bomb there is a beam of radiation that is controlled by the thick lead walls of the applicator. In most instances the radiation delivered through the walls of the plaque would be directed toward normal structures. This will tend to increase the amount of radiation reaching the bladder and rectum. These regions may be estimated to receive from one to approximately seven threshold erythema doses.

It is evident that intravaginal applicators placed against the cervix do not alter materially the distribution of radiation in

the parametrial regions. If anatomical conditions permit an application that will direct radiation toward the parametria, the doses delivered to these regions will be increased. Furthermore, if sources of radiation can be placed well out in the lateral vaginal fornices, the parametrial dose may be increased, without contributing very greatly to the amount of radiation reaching the bladder and rectum.

An intravaginal applicator used for placing sources of radiation lateral to the cervix is the so-called colpostat. This applicator consists of two cork, or rubber, containers, held together by means of a metal support. Both containers hold a capsule of radium, one being placed in each lateral fornix. The distance between the center of the capsule located in the fornix, and the lower part of the intra-uterine tandem, will vary with conditions. The distribution of radiation that is obtained from such an applica-

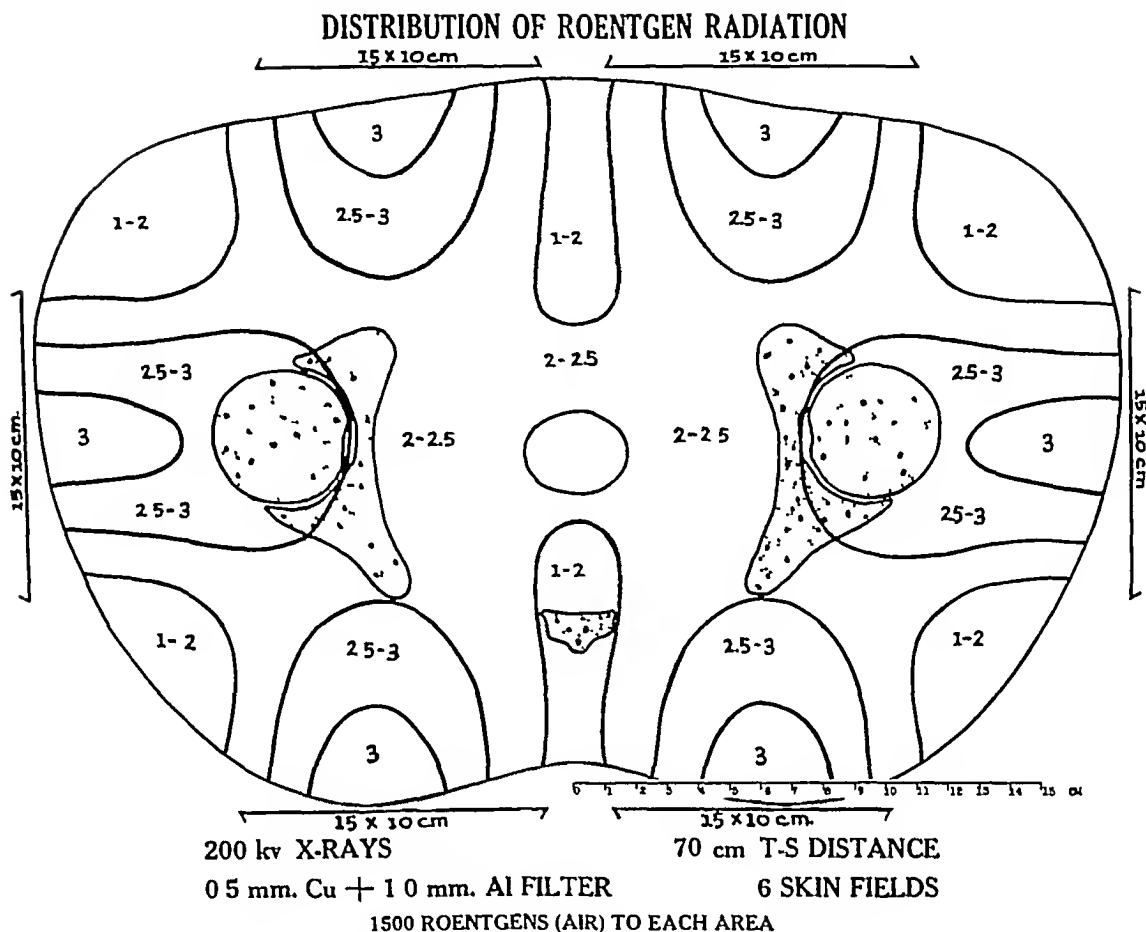


Fig 8 The distribution of threshold erythema doses within the average female pelvis for the specified factors (1,500 roentgens to each area)

distances lateral to the middle of the tandem that a lethal dose (seven threshold erythemas) is delivered, it will be noted that the tandem for 3,000 mg-hr delivers this amount of radiation to a lesser volume of tissue than any of the other methods. The volume is increased slightly by combining the tandem with the bomb, plaque, or needles, and by delivering 5,000 mg-hr from the tandem alone. The greatest increase in the distance lateral to the tandem that seven threshold erythema doses are delivered, is obtained in the method employing the colpostat. The increase is of a degree that would have justified the use of the colpostat, whenever anatomical conditions permitted such an application, even when a minimum dose of 15 threshold ery-

themas was delivered to a greater volume of tissue. The tandem and colpostat could be used for lesser doses than have been illustrated, and still deliver a lethal dose to a greater volume of tissue than has been shown for the other methods.

Finally, the amount of radiation delivered to the bladder and rectum must be considered. The doses that these structures receive will show considerable variation in individual patients. An attempt has been made to estimate the maximum amount of radiation that would be delivered in any instance. However, only the portions of the bladder and rectum adjacent to the uterus would receive these doses. Due to the rapid fall in percentage depth doses for applications of radium that



TABLE I A COMPARISON OF THE DISTANCES LATERAL TO THE INTRA-UTERINE TANDEM THAT SPECIFIED DOSES ARE DELIVERED, AND THE AMOUNT OF RADIATION REACHING THE BLADDER AND RECTUM, FOR THE DIFFERENT METHODS OF APPLYING RADIUM TO THE CERVIX

Method of Application of Radium	Cm Lateral to Lower Capsule that 15 T E D are Delivered	Cm Lateral to Middle of Tandem that 7 T E D are Delivered	Maximum Dose in T E D Delivered to Bladder and Rectum
Tandem for 3 000 mg hrs	1 0	2 0	5
Tandem plus bomb	1 3	2 1	6
Tandem plus plaque	1 3	2 1	7
Tandem plus needles	1 5	2 2	7
Tandem for 5,000 mg hrs	1 5	2 5	8
Tandem plus colpostat	3 0	3 3	7

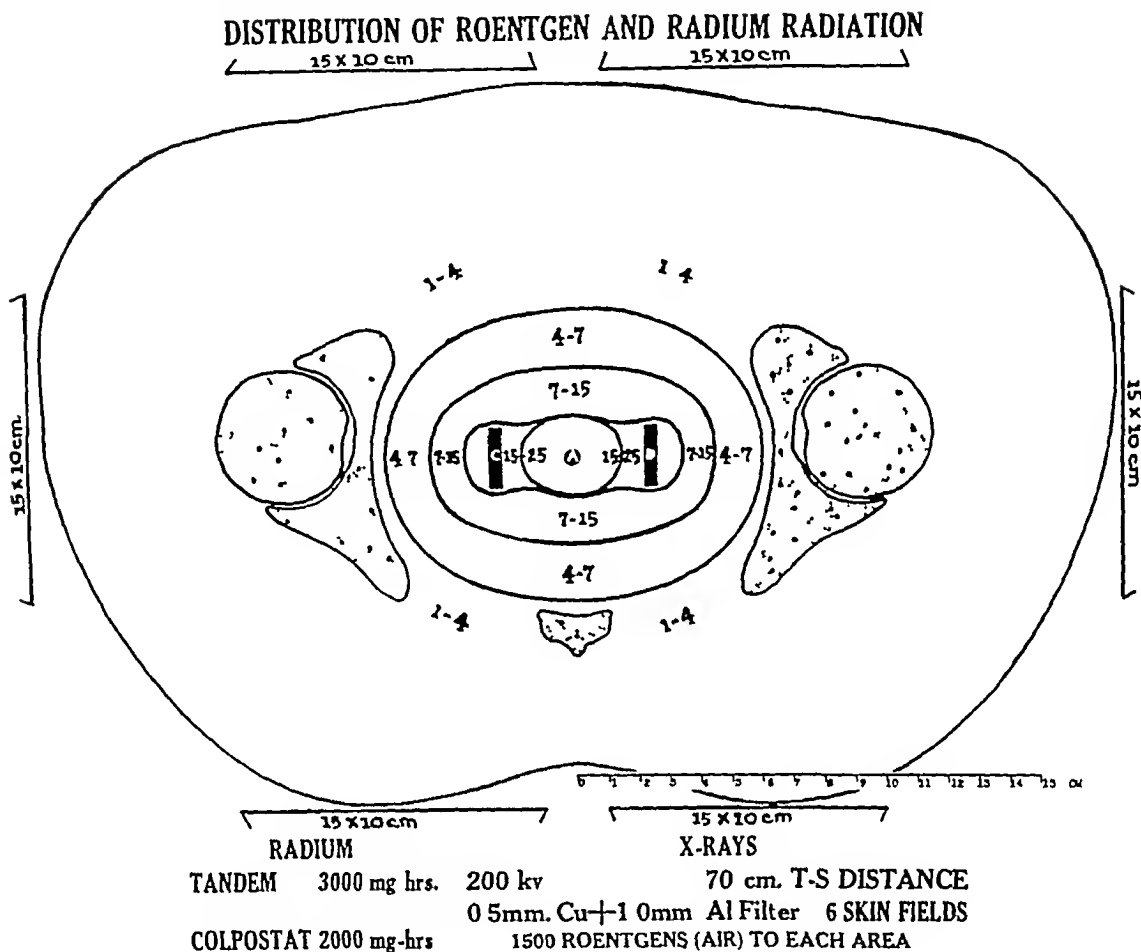
under consideration. However, in some instances it may be impossible to apply radium by any of the methods that have been discussed.

The charts presented here have been prepared for comparing the distribution of radiation from various methods of applying radium to the cervix. The criteria by which the efficiency of any method may be judged in this manner are based upon expressions of the amount of radiation reaching any given point. In each instance several factors are to be considered. The dose delivered to the primary lesion must be sufficient to control the disease in this region, but amounts of radiation that will cause a marked degree of necrosis and sloughing should be avoided. The dose delivered to the parametria is of importance for estimating the volume of tissue that receives a lethal dose. The amount of radiation reaching the bladder and rectal regions must also be noted for each method. A technic that will deliver a lethal dose to the greatest volume of tumor tissue without over-irradiating any particular region, will be the most suitable method for applying radium to the cervix.

The distribution of radiation for the various methods of applying radium has already been discussed in detail. For purposes of comparison, the points at which certain doses are delivered may be tabulated for the various technics of treatment. In considering the distribution of doses sufficient to cause necrosis and sloughing, the distance lateral to the middle of the lower capsule of the tandem that a minimum of 15 threshold erythemas is delivered will be noted. The volume of tissue that receives a lethal dose will be indicated by recording the distance lateral to the middle of the tandem that seven threshold erythemas are delivered. In each instance the maximum amount of radiation reaching the bladder and rectum will be estimated.

These data are given in Table I. It will be noted that the sequence of tabulation is different from the order in which the methods were discussed. If the column showing distances lateral to the lower capsule that 15 threshold erythema doses are delivered is considered first, it can be seen that the tandem for 3,000 mg-hr delivers this amount of radiation to a lesser volume of tissue than the other methods. Combining the bomb or plaque with the tandem increases this volume slightly. If the tandem is combined with needles, or used alone for 5,000 mg-hr, 15 threshold erythema doses will be delivered to an even greater volume of tissue. The method shown for employing the colpostat delivers this dose at the greatest distance from the lower capsule. However, as was noted in the discussion of the diagram illustrating the colpostat, this dose is delivered lateral to the cervix into a volume that is occupied chiefly by the intravaginal applicator itself. There was no region that received more than 25 threshold erythema doses. Therefore, a technic in which radium is placed lateral to the intra-uterine tandem will deliver a lethal dose to a primary lesion of greater size than any of the other methods described, without delivering excessive amounts of radiation from any particular source.

In considering the column indicating the



radium applied to the cervix delivers greater doses to points throughout the pelvis than could be obtained from either method alone. By this means the volume of tissue receiving a lethal dose will be increased, whatever the method of applying radium to the cervix. The degree of increase will depend upon the amount of roentgen radiation reaching the tumor. It has been predicted that advance in the treatment of cervix cancer will be through the improvement of the methods for delivering external irradiation.

For specified factors the distribution of roentgen radiation within the average female pelvis has already been shown in Figure 1. The size and location of the skin areas, and the manner in which the various

beams were directed, have been described. Doses delivered to points throughout the pelvis were expressed in terms of percentages of the surface dose. If the amount of radiation delivered to each field is specified, the distribution of radiation can be shown in terms of threshold erythemas. Most patients will tolerate a dose of 1,500 roentgens (air) to each of six pelvic fields, if administered over a period of at least from 18 to 24 days. In Figure 8 is shown the distribution of threshold erythema doses for this amount of external irradiation, when other factors are the same as have been given.

In Figure 9 is shown the distribution of radiation for x-rays in conjunction with the tandem and colpostat. The doses from the

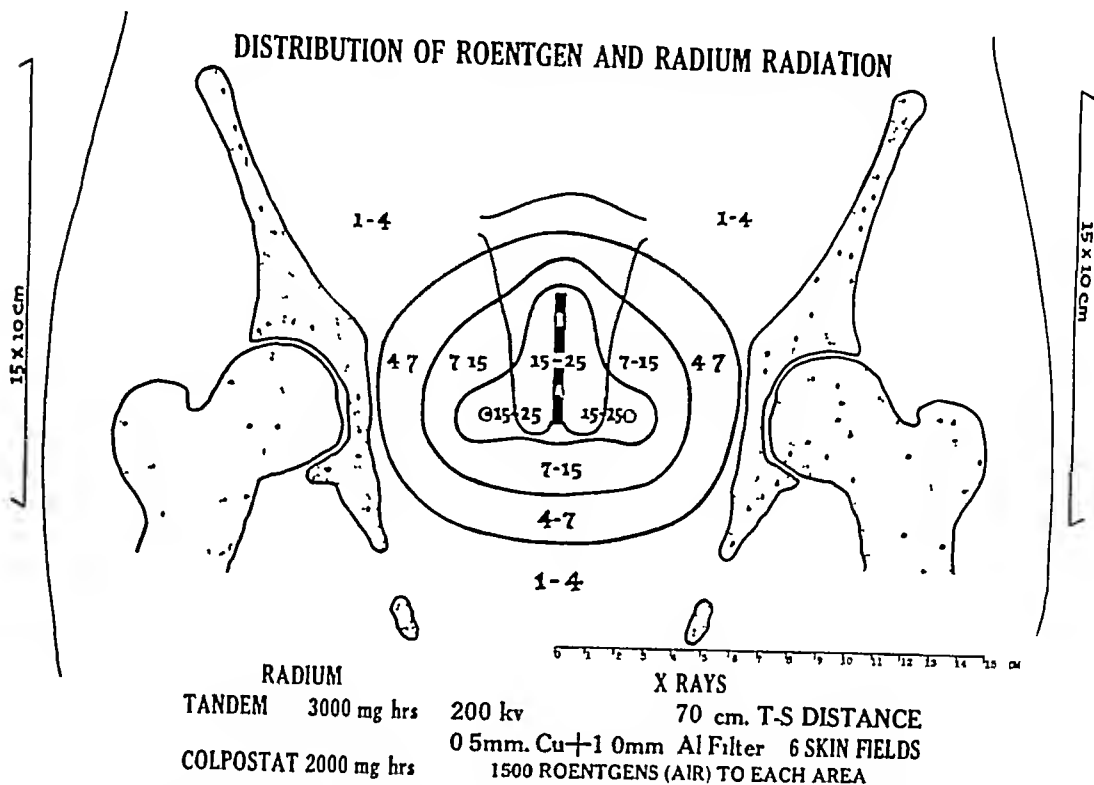


Fig 9 The distribution of roentgen and radium radiation within the average female pelvis for the methods and doses specified

have been shown, much smaller amounts of radiation would be delivered to the bulk of the bladder and rectum. From the table already referred to, it can be seen that a lesser dose is delivered to these structures by the tandem for 3,000 mg-hr than for any of the other methods. The greatest amount of radiation is delivered by the tandem for 5,000 milligram-hours. The dose these structures receive from the method employing the colpostat is about the same as is delivered by the technics that have been shown for the use of the plaque and needles.

From these comparisons it is evident that a technic employing methods for delivering radiation into the lateral vaginal fornices, in combination with an intra-uterine tandem, is the most suitable for the treatment of cervix cancer. It has also been shown that, for doses within reasonable limits of tissue damage, it is impossible to deliver a lethal amount of radiation for a

distance of more than three or four centimeters lateral to the tandem. For control of the disease beyond the zone of effect by radium applied to the cervix, some other means of treatment must be employed. External irradiation by roentgen rays is the method used most frequently for this purpose. Since the parametria are involved in most instances, the administration of roentgen radiation is just as important as the application of radium to the cervix. The amount of external irradiation that must be delivered for treating adequately the tumor in the parametrial regions, will usually produce some constitutional reaction in the patients receiving the dose, and an erythema of a rather marked degree in the irradiated skin fields. It is important, therefore, that the tissue damage at the site of the application of radium be limited to a degree that will not interfere with the administration of roentgen rays. The use of roentgen radiation in conjunction with

are indicated in the median sagittal view of the pelvis, shown in Figure 11. Most of the bladder receives from four to seven threshold erythema doses. However, there is a portion near the uterus to which a maximum dose of about ten threshold erythemas might be delivered. The rectum receives about four to seven threshold erythema doses.

The doses that have been indicated for points throughout the pelvis probably represent the maximum amount of radiation that can be delivered safely to most patients. In many instances it may be necessary to employ lesser amounts than have been shown. For other doses, or patients presenting different anatomical conditions, these data are not directly applicable. They may, however, be used as a basis for approximating the amount of radiation delivered to any particular region.

#### SUMMARY AND CONCLUSIONS

The distribution of radiation throughout an average female pelvis has been studied for a variety of methods for applying radium to the cervix. A comparison can be made of the relative effectiveness of the various methods considered. For each plan, the distribution of radiation has been illustrated by showing differences of several threshold erythemas, which have been grouped according to greater or lesser amounts of radiation than the supposed lethal dose for cervix cancer. The reasons for employing this unit for expressing doses delivered to points throughout the pelvis have been given. It has been shown that a technic employing methods for delivering radiation into the lateral vaginal fornices, in combination with an intra-uterine tandem, delivers a distribution of radiation that is best suited to the treatment of cervix cancer. The colpostat can be used for this purpose, by means of which a lethal dose is delivered to a greater volume of tissue, without over-irradiating any region, or delivering excessive doses to the bladder or rectum.

It has been shown that, for doses within

reasonable limits of tissue damage, it is impossible to deliver a lethal amount of radiation for a distance of more than three or four centimeters from the intra-uterine tandem. Roentgen treatment is the method most frequently used for delivering radiation to parametrial disease beyond the zone of effect by radium applied to the cervix. We have illustrated the addition of specified doses of roentgen rays to the radiation from an intra-uterine tandem in combination with a colpostat whereby the volume of tissue that receives a lethal dose is increased. Advance in the treatment of cervix cancer will be made by improving the methods for delivering external irradiation, rather than in employing different technics for applying radium to the primary lesion.

Due to the variation in the anatomical conditions presented by individual patients, no single plan is suitable for the treatment of all cases. In some instances it may be impossible to apply radium by any of the methods that have been considered. However, it is considered desirable to deliver radiation into the vaginal fornices, whenever anatomical conditions permit such an application. Despite the fact that the charts illustrate certain specified conditions, it will readily be seen that the data given for each technic can be applied to other cases, when the anatomical conditions and the dimensions of the uterus and pelvis, are known.

The author wishes to express his appreciation to Dr. Sherwood Moore, Dr. Otto Schwarz, and Dr. Q. U. Newell, of Washington University, and to Dr. W. P. Healy, of Memorial Hospital, New York, for their interest and advice during the course of this work. He also wishes particularly to acknowledge his indebtedness to Mrs. Edith Qumby, of Memorial Hospital, who supplied the data on which the isodose curves for radium are based, and offered many constructive suggestions. Without her co-operation, it would have been impossible to have written this paper.

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# DISTRIBUTION OF ROENTGEN AND RADIUM RADIATION

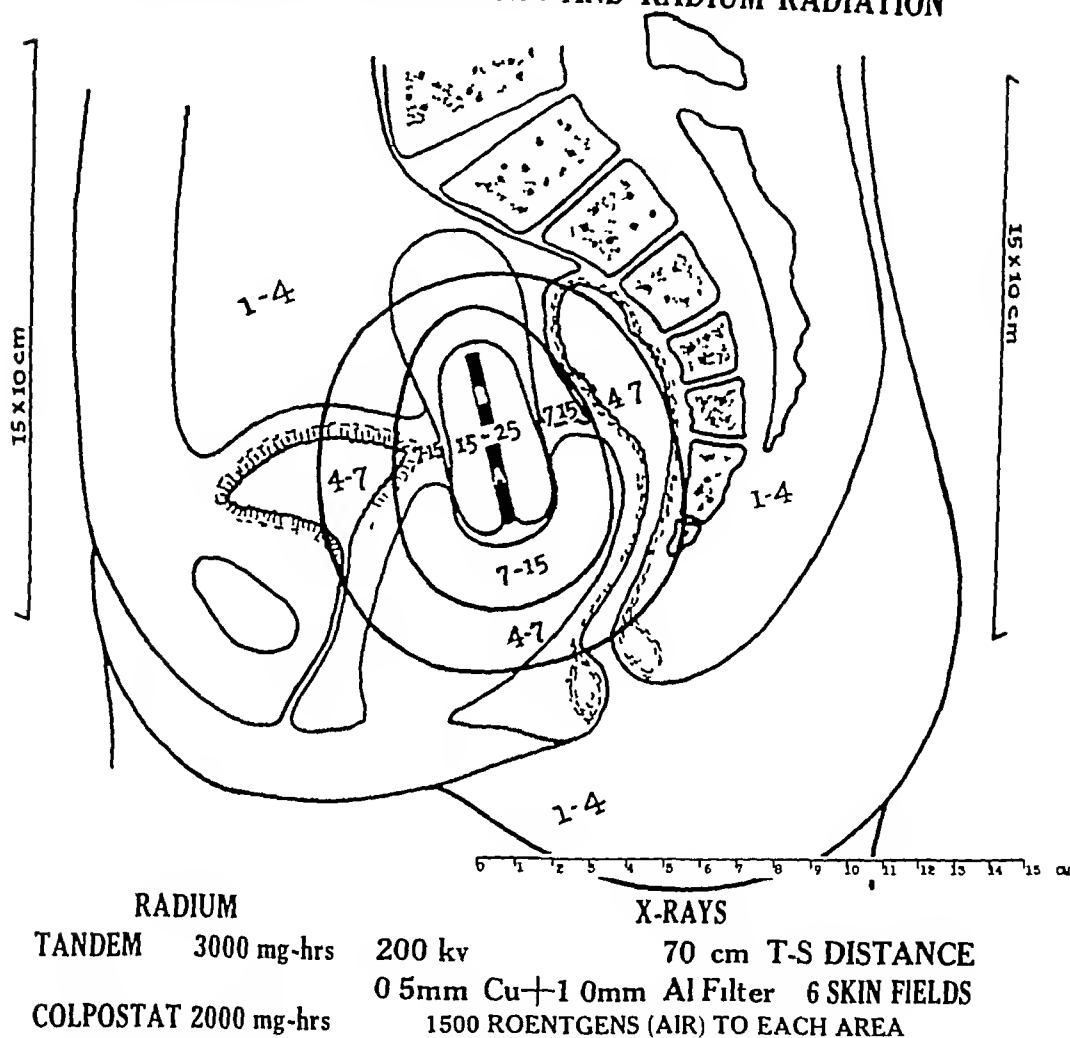


Fig 11 The distribution of roentgen and radium radiation shown in a median sagittal section of the average female pelvis

sources of radium radiation are the same as have been shown for this type of application. From the diagram it can be seen that a lethal tumor dose (seven threshold erythemas) is delivered into the parametrial regions for a distance of about 4.5 cm from the middle of the tandem. Four threshold erythema doses, which would produce marked changes in the tumor, are delivered almost to the lateral pelvic walls. The remainder of the pelvis receives from one to four threshold erythemas.

The distribution of radiation in a transverse view of the pelvis is shown in Figure 10. Specified doses are delivered for a greater distance lateral to the tandem, than in the anterior or posterior direction. This is due to the sources of radium radiation that are located in the vaginal fornices, a fact which illustrates the advantage of such applicators as the colpostat for delivering a distribution of radiation suitable to the treatment of cervical cancer. The doses delivered to the bladder and rectum

# THE X-RAY ASPECTS OF PNEUMOCONIOSIS<sup>1</sup>

By L. H. GARLAND, M. B., *San Francisco*

THE early detection and correct classification of pneumoconiosis is still one of the difficult problems in diagnostic roentgenology. It may, therefore, be of interest to summarize recent observations concerning the diagnosis and differential diagnosis of the disease, and to discuss its classification from the point of view of the clinical radiologist.

Pneumoconiosis has been defined as the series of injurious changes, fibrotic and usually progressive in character, produced in the lungs by the inhalation of unusual quantities of certain dusts. While dust containing particles of silica is the chief offender, it is now known that certain silicates, coal dust, and other dusts also produce changes. Some workers believe that sericite, hydrous aluminum silicate, rather than silica,  $\text{SiO}_2$ , is the principal noxious agent, but agreement is far from complete on this point. Cummins (1) recently observed that "silicosis" may yet be found to be "silicatosis." The majority favor silica as the cause and believe that it produces specific changes in the cells of the lung either on account of its colloidal properties or by acting as a protoplasmic poison (16). In spite of modern preventive methods in industry, it is alleged that the incidence of pneumoconiosis is increasing. It is quite certain that the industrial production of fine silica powder, now an important constituent of many chemical compounds in daily use, is on the increase. Lanza and Vane (7) estimate that over half a million workers in the United States are exposed to the silica-dust hazard (and that the mortality from tuberculosis is appreciably affected by such).

## TECHNIC OF ROENTGEN EXAMINATION

The diagnosis of pneumoconiosis is based on (1) the history, (2) the clinical findings, and (3) the roentgen findings.

<sup>1</sup>Read before the San Francisco County Medical Society, Sept. 17, 1935.

The weakest link in the chain is the clinical examination and the strongest the roentgen evidence. The diagnosis requires the intelligent correlation of all three types of data, and, since it constitutes the strongest link, the most thorough type of roentgen examination. This examination should include (a) a careful fluoroscopic examination, to aid in the detection of complicating emphysema, pleural adhesions, cavities, and right-sided cardiac enlargement, and (b) clear sharp teleroentgenograms made in  $1/20$  of a second or less. The latter should consist of stereoscopic anterior and plain lateral films, as a minimum procedure, the importance of intensifying screens with good contact cannot be over-emphasized. Re-examination at the end of four weeks is frequently necessary to exclude the existence of complicating acute inflammatory processes which may exaggerate a mild fibrosis at the initial examination. In the average mild or early case, re-examination at intervals of one year for a three-year period is necessary to determine whether or not the changes are progressive in character. We would like to draw attention to the enormous sums now being spent both in compensation to workers disabled by pneumoconiosis and in protracted litigation. We believe that the time has come when an adequate type of roentgen examination should be instituted in all routine surveys of workers and applicants for work in daily occupations. The commonly seen "single postero-anterior film," often made with an inefficient and antiquated portable x-ray unit, seems like a very false type of economy when one considers both the health and the financial risk involved.

## ROENTGEN DIAGNOSIS AND CLASSIFICATION

The roentgen appearance of the lungs in pneumoconiosis is so variable that a brief description of the findings, irrespective of the stage and type of the disease, is

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Fig 3

Fig 4

Fig 3 Roentgenogram showing pneumoconiosis, incipient type. Hilar shadows wider and denser than normal, thickening of the perihilar pulmonary tree markings. Finnish miner, aged 46 years, with no pulmonary symptoms, had been doing hard rock mining for several years. (Roentgenograms made on account of cervical cellulitis following a neck wound.) Roentgen interpretation: probable mild pneumoconiosis.

Fig 4 Roentgenogram showing pneumoconiosis, early interstitial type. Hilar shadows are slightly increased in width. There is a thickening of the smaller pulmonary tree markings in the middle two-thirds of both lungs, there is a hazy appearance of the middle third of the left lung. Austrian baker, aged 37 years, suffered with chronic parenchymatous nephritis and secondary anemia. He had a slight cough and nocturnal dyspnea. Roentgen interpretation: possibly miliary tuberculosis, early pneumoconiosis or passive congestion. Necropsy, five months later showed extremely marked anthracosis, with some fine patchy fibrosis, no parenchymal tubercles, but several tiny, healed, pleural tubercles. Also chronic nephritis, slight ventricular hypertrophy and so forth.

does not clarify the variation in types seen, nor the fact that while many Stage I cases progress to nodular changes in Stage II, others remain interstitial in type throughout the course of the disease (diffuse fibrosis). Most authors describe Stage I as showing increased density and widening of the hilar shadows, with thickening of the perihilar linear markings, other authors, on the grounds that these changes are not typical of pneumoconiosis, describe Stage I as a fine mottling in the center of the lung-fields with perihilar thickening.

For purposes of classification, we shall outline what is generally understood by the Three Stage Classification, then we shall reproduce the pathologico-roentgenologic

classification recommended by some well-known authorities, and, since this appears too complex for general use by the clinical radiologist, we shall outline a simple classification which, in our opinion, satisfactorily covers the problem.

In summarizing the roentgen appearance visible in the various stages or types, it is to be remembered that these changes usually are by no means pathognomonic, however, they are the changes visible in roentgenograms in the majority of cases of uncomplicated occupational pulmonary fibrosis.

#### (A) The "Three Stage" Classification

Stage I. Hilar shadows slightly wider and denser than normal, pulmonary tree





Fig 1

Fig 2

Fig 1 Roentgenogram showing a normal chest. Normal adult thorax (male, aged 38 years), at full inspiration. Normal fibrovascular hilar and parenchymal (or pulmonary tree) markings. Normal diaphragmatic position and outline.

Fig 2 Roentgenogram showing a normal chest. Normal adult thorax (same patient as in Figure 1 made on the same day) at full expiration. Note how the hilar markings are widened and the middle and lower pulmonary tree markings are accentuated. Elevated diaphragm. (Exposure technic and development identical with that used in Figure 1.)

impossible. This is quite natural, since the roentgenograms clearly reflect the morbid changes present, and these are highly variable. The text-book picture of "diffuse mottling, symmetrically distributed throughout both lung-fields, but usually sparing the apices" is observed frequently in large surveys of mine workers, but is far from being the most usual type seen in general radiologic practice in our experience.

Since the type and especially the stage of the disease influences the roentgen picture so strongly, it will be well to discuss the classification of pneumoconiosis before considering the roentgen diagnostic features in detail. From the roentgenologic point of view it is customary to classify the disease into three stages. Reichmann (5) considers this division useless and incorrect, since in his opinion no sharp limit can be drawn between the first and second stages, in-

deed, it may happen that the disease will pass directly from the first to the third stage without presenting any features of the second stage. Some confusion exists owing to the fact that some authors report as *stages* of the disease what other authors report as *types*. The fact of the matter seems to be that the types are so multitudinous that it is almost impossible to group them all into any brief pathologic or roentgenologic classification, however, an attempt at such is necessary for purposes of simplifying diagnosis and understanding the progress of the disease. Since most well established cases are fundamentally progressive in nature and fibrotic in type, the simple division into three stages, based on early, moderate, and advanced changes is popular and, indeed, still official with some authorities (*cf* the reports of the International Silicosis Congress in Johannesburg). However, this



Fig 7



Fig 8

Fig 7 Roentgenogram showing pneumoconiosis, marked nodular type. Diffuse scattering of small soft nodules throughout both lung fields with some coalescence of the nodules in the lower half of the left lung possible cavitation in the left upper lobe emphysema at both bases with some flattening of the left diaphragm

American miner elderly, with dyspnea Roentgen interpretation pneumoconiosis nodular type, with possible associated tuberculosis (no clinical evidence of the latter)

Fig 8 Roentgenogram showing pneumoconiosis marked nodular type. Diffuse scattering of small, discrete fairly firm nodules throughout both lung-fields. Slight flattening of the diaphragm at both bases

Italian miner aged 69 years complained of weakness but no dyspnea. He had done all kinds of mining for many years. Roentgen interpretation pneumoconiosis, marked. Necropsy eight months later revealed marked pneumoconiosis patient also had carcinoma of the stomach, marked secondary anemia, etc

### (C) *A Simplified Roentgenologic Classification*

- (1) Incipient type
- (2) Interstitial type
- (3) Nodular type
- (4) Advanced type

1 *Incipient type*—The hilar shadows are wider and denser than normal, the perihilar pulmonary tree markings are wider than normal

2 *Interstitial type*—In addition to the above findings, in early cases there is a faint haze in the middle or lower thirds of the lungs, and in well established cases there is diffuse thickening of the smaller pulmonary tree markings. Limitation of diaphragmatic excursion varies from slight to marked

3 *Nodular type*—The hilar shadows

are wider and denser than normal, there is diffuse mottling throughout both lungs, especially in the middle and lower thirds, the shadows being small, dense, and discrete, the apices are usually free, there is moderate or marked limitation of diaphragmatic excursion

4 *Advanced type*—The hilar shadows appear to be less prominent than in the second and third types, there is diffuse thickening of the pulmonary tree markings with or without diffuse nodulation. There are small or large areas of density due to coalescence of fibrotic nodular lesions, there is emphysema, limitation of diaphragmatic excursion, and sometimes cavi-

\* Since this classification is largely self descriptive we shall omit a detailed list of the roentgen findings for purposes of brevity



Fig 5

Fig 6

Fig 5 Roentgenogram showing pneumoconiosis early nodular type Right hilum widening, thickening of the smaller pulmonary tree markings throughout most of the lungs, thickening of the larger pulmonary tree markings at the right base mesially slight nodulation

American miner aged 84 years who had Osler Vaquez disease and splenomegaly He had been a stone cutter and miner for several years Roentgen interpretation irregular pulmonary fibrosis possibly pneumoconiosis Necropsy some months after this film was made showed fibrosis especially of the left lower and right upper lobes interpreted as mild pneumoconiosis The patient had broken his hip and had developed bronchopneumonia

Fig 6 Roentgenogram showing pneumoconiosis, nodular type Hilar shadows broadened and increased in density thickening of the smaller pulmonary tree markings and soft nodulation throughout both lungs moderate flattening of both diaphragms confluent density at the right base mesially American miner, aged 41 years who had dyspnea for one year and cough with weight loss for six months Roentgen interpretation pneumoconiosis nodular type Stage II

markings slightly thicker than normal, occasional hazy appearance about the middle, or middle and lower thirds of the lungs

Stage II The above changes are more marked, slight diffuse nodular thickening of the pulmonary tree markings, slight or moderate limitation of diaphragmatic excursion

Stage III Diffuse thickening of the pulmonary tree markings, with or without diffuse scattering of small discrete nodules, limitation of diaphragmatic excursion, emphysema, occasional coalescence of areas of fibrosis or nodulation, enlargement of the right side of the heart, hilar shadows

less prominent than usual, occasional cavitation

(B) *The Detailed Pathologico-roentgenologic Classification of Pancoast and Pendergrass<sup>2</sup>*

- |     |  |  |
|-----|--|--|
| (1) | Peribronchial perivascular lymph node predominance                       | { rapid<br>{ slow  |
| (2) | Early interstitial predominance (interferes with diaphragmatic movement) | { with nodular appearance<br>{ without nodular appearance<br>{ rapid or slow |
| (3) | Late or advanced interstitial predominance                               |  |
| (4) | Nodular predominance   | { non progressive<br>{ progressive   |
| (5) | Advanced diffuse or terminal fibrosis                                    | { conglomerate nodular<br>{ interstitial type<br>{ massive fibrosis type     |



Fig 11

Fig 11 Roentgenogram showing pulmonary syphilis simulating pneumoconiosis. Diffuse patchy thickening of the small pulmonary tree markings, coalescent areas of fibrosis at both bases.

American gardener aged 69 years complained of pain in the chest for four months with occasional cough and hemoptysis. He had never done any mining. Sputum was negative for tubercle bacilli on six examinations. Temperature, pulse and respiration were normal. Wassermann reaction was three plus. Clinical diagnosis: bronchiectasis, chronic pulmonary tuberculosis, arteriosclerosis. Roentgen interpretation as follows: diffuse pulmonary fibrosis, possibly tuberculous or syphilitic, bronchiectasis. The patient improved under anti-syphilitic therapy but later failed. Necropsy five months later showed diffuse pulmonary fibrosis, bronchiectasis, chronic adhesive pleurisy, but absolutely no evidence of tuberculosis, microscopic or otherwise, nor any evidence of mycotic infection, etc. Final diagnosis was *probable* interstitial syphilitic fibrosis of the lungs.

Fig 12 Roentgenogram showing pulmonary syphilis simulating pneumoconiosis. Right hilum increased in width, extensive linear thickening of the pulmonary tree markings in the upper two thirds of both lung-fields, extensive emphysema at both bases with irregularity of the right diaphragm.

Italian elevator operator aged 57 years complained of weakness, weight loss and pains in the chest. Sputum was repeatedly negative for tubercle bacilli. Temperature, pulse and respiration were normal. Blood Wassermann was two plus. Clinical diagnosis: chronic bronchitis and syphilis. Roentgen interpretation as follows: peculiar bilateral pulmonary fibrosis, probably old tuberculosis, left apex, possible syphilitic fibrosis. Patient died seven months later. Necropsy showed marked syphilitic aortitis, diffuse fibrosis of both lungs without any microscopic evidence of tuberculosis, mycosis or other granuloma. Stains for spirochetes unsuccessful. Dark field examination of sputum not done.

cosis are chiefly confined to the posterior portions of approximately the middle third of the lungs. He believes that the postero-inferior portion of the upper lobe and the postero-superior portion of the lower lobe show most of the changes. These areas correspond to the distribution of two bronchial branches, the dorso-lateral branch of the upper lobe bronchus and the first dorsal branch of the lower lobe bronchus. While such a well localized distribution may occur in Swedish porcelain workers,

it does not appear to occur in general types of pneumoconiosis in our experience.

In connection with the diagnosis of emphysema, it is now believed that the position of the diaphragm and the apparent increase in translucency of the chest are not reliable roentgen signs. Flattening of the diaphragm and poor mobility is of some aid. Pancoast and Pendergrass (13) believe that the most reliable evidence is found in the lateral films. In emphysema, owing to hyper-aeration of certain portions



Fig 9

Fig 9 Roentgenogram showing pneumoconiosis, advanced type. Patchy thickening of the smaller pulmonary tree markings in several areas of both lungs, massive coalescence of areas of nodulation in the right lower lung field and at the left base.

Italian farm laborer, aged 60 years, had pernicious anemia and subacute combined sclerosis. He had been a hard rock miner for several years. Roentgen interpretation: partial consolidation of the right middle lobe, either inflammatory or neoplastic; possible metastatic neoplasm in both lungs. Necropsy several months later revealed marked fibrosis of both lungs (pneumoconiosis, advanced), plus a small cavity in the right lung from which a few tubercle bacilli were recovered.

Fig 10

Fig 10 Roentgenogram showing tuberculosis simulating pneumoconiosis. Diffuse mottling of small discrete nodules throughout the right and left lungs, with some shrinkage of the left lung and pleural thickening around the left upper lobe.

Scottish hostler, aged 58 years, had a cough, thoracic pain, and dyspnea. He gave no history of mining. Sputum was positive for tubercle bacilli on several occasions. Roentgen examination two years previously showed left upper lobe pulmonary tuberculosis with cavitation. In view of this it is evident that the patient has recently developed disseminated miliary pulmonary tuberculosis. Death: no necropsy.

tation. The right side of the heart is often enlarged.

Any of these types may be slowly or rapidly progressive, and may be complicated by any of the lesions mentioned below. The disease is usually more or less progressive in persons who have been exposed over long periods of time, but it is well recognized that persons with exposures of short duration to moderate quantities of dust may show no changes at all, while persons exposed to unusually massive amounts of silica (for example, in the pulverized sand industries) may develop a rapidly fatal disease with little macroscopic fibrosis or nodulation. In cases of

this type, no separate stages are detectable. In mild cases of ordinary silicosis, a stationary phase may develop after cessation of exposure. The roentgen appearance is rendered confusing by the development of an associated pulmonary tuberculosis in many cases, which may arise by fresh infection or by so-called reactivation of a clinically obsolete focus. The "typical" progress of the disease will then be altered according to the severity of the tuberculous lesion.

Jonsson (5), on the basis of studies of lateral roentgenograms of a large number of porcelain workers, believes that the pulmonary lesions in uncomplicated sil-

single factor is a history<sup>3</sup> of exposure to dust

In *passive congestion* of the lungs, the heart frequently will be enlarged to the left, there may be some fluid in the bases of the pleural cavities, and the perihilar shadows will be very broad in proportion to the peripheral linear shadows. Re-examination after compensation has been established will disclose disappearance of many of the vascular markings. The *acute respiratory* infections will be differentiated by the marked symptoms and by serial examination. In *asthma*, the hilar markings, while broadened, are not so dense and homogeneous as in early pneumoconiosis.

There are no really satisfactory differential features between early interstitial pneumoconiosis and some of the *chronic respiratory infections*. Serial examination and knowledge of the patient's occupation are essential. The same applies to polycythemia, metastatic infiltrating malignancy, and mycotic infections. Infiltrations of leukemic and lymphoblastomatous origin will clear up rapidly under moderate doses of radiation therapy.

The nodular type of pneumoconiosis may simulate *miliary tuberculosis*. In the latter, the mottling is usually softer, more hazy, and more uniformly distributed than in pneumoconiosis. Fluoroscopically, one will be aware of the sick condition of the tuberculous patient and the relative lack of symptoms of the average pneumoconiotic, in addition, diaphragmatic limitation is more apt to be present in the latter. Usually, miliary carcinosis is rapidly fatal. Periarthritis nodosa, which is rarely encountered, may be differentiated by the absence of an appropriate history and by other points, according to v Conta (17)

<sup>3</sup> This history is frequently difficult to elicit. Elderly males often will give their occupation as janitor or elevator operator. When asked if any other one was followed they will often say, "No." One must ask the specific questions. Have you ever done any mining or worked in dusty occupations before you took up your present work? For how many years? What exact type of work was done?" etc

The advanced type of pneumoconiosis frequently resembles *chronic pulmonary tuberculosis*, and of course is often complicated by that disease. However, a number of cases uncomplicated by tuberculosis are encountered, and in addition, many bizarre forms are seen. Chronic tuberculosis usually involves the upper rather than the lower two-thirds of the lungs, the lesions tend to show calcification and pleural changes are more marked. The hila tend to be dislocated upward rather than laterally, and the trachea to be displaced to one side. Healed miliary tuberculosis has been confused with pneumoconiosis, usually the spots are sharper, denser, and more regularly distributed than in the latter disease, and there is much less fibrosis. *Pulmonary tumors* rarely simulate pneumoconiosis, but the converse occurs not infrequently. Large coalescent areas of fibrosis or nodulation may perfectly mimic single or multiple metastatic tumors. Differentiation may be made by the detection of a primary, by evidence of growth on serial examination, by the presence of appropriate symptoms, and the lack of an occupational history. Pulmonary syphilis is such a debatable subject that we shall not consume space here with a discussion of its particular features, suffice it to say that cases clinically diagnosed as chronic interstitial pulmonary fibrosis, in persons with clinical and serologic signs of syphilis and without evidence of tuberculous or mycotic infection and with no history of exposure to dust, have been reported. The roentgen findings may be indistinguishable from those of the interstitial type of pneumoconiosis.

#### COMPLICATIONS

Most cases of pneumoconiosis develop insidiously and are chronic. Indeed, many cases show a long latent period between exposure and the development of demonstrable fibrosis. The most common complications are emphysema, limitation of diaphragmatic excursion, and pleural thickening. Severe cases develop bronchiectasis and even cavities (so-called black phthisis,

of the lungs, the anterior and posterior mediastinal air-shadows are widened, the space between the heart and sternum, and the retro-cardiac space will be greater than normal. We have not been impressed with the value of this evidence, and find the diagnosis of moderate emphysema quite difficult.

#### DIFFERENTIAL DIAGNOSIS

The detection of pneumoconiosis in its early stages demands familiarity with the *normal roentgen appearance* of the adult lung. We tend to forget that the normal hilar and pulmonary tree shadows are largely vascular in origin, and that the latter are subject to exaggeration or obliteration by over-lying pectoral shadows, respiratory and cardiac movements, and by incomplete inspiration (Figs 1 and 2).

The normal hila are composite shadows made up of the bronchi, pulmonary vessels, lymph nodes, and connective tissue around the roots of the lungs. While highly variable, the Normal Chest Committee (10) have defined the normal standards as follows:

"The constituent trunk or vessel shadows should be distinguishable under normal exposures, the hilus should not be made up of any solid mass of homogeneous shadow. The right hilum extends from the top of the right main bronchus to the point of division of the right lower lobe bronchus. The left hilum extends from the upper portion of the pulmonary artery shadow to the point of division of the left lower lobe bronchus."

Sampson (15) writes

"In considering the very slight alteration in the pulmonary field which insignificant anatomical changes produce, one must bear in mind certain manifestations of the normal chest, the movement of the pulmonary markings at the left base due to the heart beat may well be mistaken for the cloudiness expected in early silicosis. Similarly, the shadow of the margin of the pectoralis muscle is not unlike that shadow seen in cases of beginning fibrosis. However, the shadow of the muscle is situated more peripherally and continues beyond the pulmonary field, while the intrapulmonary haziness of silicosis is usually more centrally located. Also, in the

case of the pectoralis muscle the lung markings are visible through the shadow of the muscle, whereas the enveloping intra-pulmonary infiltration produces cloudiness which tends to obscure the vascular ramifications. In general, if the cloudiness, which has not yet assumed the nodular appearance, is confined to the region of the pectoralis muscle or to the left base, and if no alteration of the pulmonary pattern is seen above this level, we may not be justified in believing we are dealing with a pathologic process. After the stage of nodulation has been reached it is not difficult to recognize characteristic mottling."

The following diseases must be taken into consideration in the differential diagnosis of pneumoconiosis in its various types:

*Incipient Type*—The incipient type may be confused with

Passive congestion of the lungs (cardiac),  
Acute respiratory tract infections,  
Asthma

*Interstitial Type*—The interstitial type may be confused with

Passive congestion of the lungs (cardiac),  
Acute and chronic respiratory infections  
(especially bronchitis and broncho-sinusitis),  
Polyeythemia,  
Lymphoblastoma (infiltrative Hodg-kin's),  
Mycoses,  
Pulmonary syphilis

*Nodular Type*—The nodular type may be confused with

Miliary tuberculosis,  
Metastatic malignancies (miliary carcinoma),  
Periarteritis nodosa

*Advanced Type*—The advanced type may be confused with

Chronic pulmonary tuberculosis,  
Pulmonary tumors,  
Pulmonary syphilis

From the roentgenograms alone it is often quite impossible to differentiate between some of the above disorders and pneumoconiosis. While the following points will be found of assistance in many cases, unquestionably the most valuable

TABLE IV—DIFFERENTIAL ROENTGEN DIAGNOSIS BETWEEN COMMON TYPES OF PNEUMOCONIOSIS AND TUBERCULOSIS

<i>Pneumoconiosis</i>	<i>Tuberculosis</i>
(A) <i>Nodular Type</i> Soft or dense discrete spots," varying in size irregularly scattered throughout both lungs, usually more marked centrally apices usually free, emphysema occasionally marked, pleural involvement slight diaphragm movement limited	(A) <i>Miliary Type</i> Soft, fuzzy "spots," small and uniform in size evenly scattered throughout both lungs, as marked peripherally as elsewhere, apices involved emphysema rare, pleural involvement common diaphragm movement often normal
(B) <i>Advanced Fibrotic Type</i> Lesions often in lower two-thirds of lungs with irregular emphysema, trachea often displaced backwards, hila often displaced laterally cavitation and calcification rare, pleural involvement occasional diaphragm excursion limited	(B) <i>Chronic Fibroid Type</i> Lesions often in upper two-thirds of lungs, with basal emphysema, trachea often displaced laterally, hila often displaced upwards, cavitation and calcification common, pleural involvement frequent, diaphragm excursion moderately limited

(Combinations of pneumoconiosis and tuberculosis, including silico-tuberculosis, may show predominant tuberculous changes)

A very acute type of silicosis occurs among the workers in certain abrasive soap, scrubbing powder, glass, and vitreous paint industries, especially among packers of siliceous scouring powders (6). The roentgen findings in these cases consist of a faint, hazy nodulation, but with early limitation of diaphragmatic excursion. The disease may be so rapidly fatal that no second or third stage is manifested, the patients virtually die with a sub-acute interstitial pneumonia.

In asbestosis, the roentgenograms show a fine, diffuse pulmonary fibrosis, often commencing at the bases and spreading upward, the hilar markings are heavy and there is restriction of diaphragmatic movement (18). While isolated asbestosis bodies may be found in the sputum, they do not necessarily have clinical significance (Ellman, 2).

For several years it was believed that soft-coal handlers did not develop true pulmonary fibrosis, but merely densely pigmented lungs (anthracosis). However, it is now believed that some cases of anthracosis are associated with fine pul-

monary fibrosis—benign anthracosis, in contradistinction to silico-anthracosis, which predisposes to tuberculosis (13). Coal miners illustrate very well the length of time usually required to produce marked fibrotic changes. This, of course, indicates that there is a low concentration of silica in the dust in question.

#### X-RAY TESTS OF FUNCTIONAL DISABILITY OF THE LUNGS

The clinically significant factors in pulmonary pneumoconiosis usually are the amount of functional disability of the lungs and the presence of complicating tuberculosis. In addition to the usual diagnostic roentgen examination, McCann *et al* (8) studied many cases by area measurements of the pulmonary fields during maximum inspiration and expiration, and made records of the position of the ribs and the diaphragm. The results of these combined measurements indicated that in general the degree of disability parallels the degree of fibrosis present. However, many exceptions to this were found which emphasized the fact that one cannot accurately judge the degree of pulmonary disability by the roentgenograms alone.

#### X-RAY EXAMINATIONS OF SAMPLES OF DUST-CONTAINING AIR

We have recently seen reports on the use of x-rays to determine the concentration of silica in samples of air (Clark and Reynolds, University of Illinois, speaking at the 1935 American Chemical Society meeting in San Francisco). Since all workers believe that only silica particles of very small size are involved in the production of pneumoconiosis, and since some authors have suggested that there may actually be a critical size of particle involved, varying from 6 to 10 micra, it does not appear probable at first glance that this type of examination will be of great assistance. The particles must be small enough to float into the alveoli and be engulfed by endothelial cells, most being probably less than 6 micra in size.



TABLE I — ROENTGEN FINDINGS IN PNEUMOCONIOSIS

(UNCOMPLICATED OR SIMPLE PNEUMOCONIOSIS)

- 1 Incipient Type  
Hilar shadows wider and denser than normal  
perihilar pulmonary tree markings wider than normal
- 2 Interstitial Type  
Hilar shadows wider and denser than normal, slight or moderate diffuse thickening of the pulmonary tree markings, associated with faint haze in middle or lower thirds of the lungs in early cases, extensive thickening in well established cases,  
Limitation of diaphragmatic excursion (varying from slight to marked)
- 3 Nodular Type  
Hilar shadows wider and denser than normal, diffuse scattering of small, dense, discrete nodules throughout both lungs, especially in the middle thirds apices usually free  
Imitation of diaphragmatic excursion
- 4 Advanced Type  
Hilar shadows less prominent than usual diffuse thickening of the pulmonary tree markings, and/or diffuse nodulations, small or large areas of density due to coalescence of fibrotic or nodular lesions,  
Emphysema  
Limitation of diaphragmatic excursion,  
Occasional cavitation  
Enlargement of the right side of the heart

the cavities being in the middle or lower lobes and non-tuberculous in nature) Spontaneous pneumothorax has been reported in a fair percentage of cases. Right-sided cardiac enlargement is not uncommon and cardiac failure supervenes in many advanced cases. Chronic indurative pneumonia with small or large areas of atelectasis has been reported. Bronchiogenic carcinoma is a rare complication. It is noteworthy that among many hundreds of cases, Pancoast and Pendergrass saw only three proven cases of primary lung cancer. They do not believe pneumoconiosis is a predisposing cause of bronchiogenic carcinoma.

Tuberculosis is the most serious complication and occurs in a variable percentage of cases, depending in part on the type of work involved. In a survey of 800 porcelain workers, Flemming-Moller (3) found a remarkably low incidence (1.7 per cent). On the other hand, in certain mining industries, the incidence of tuberculosis has been found to be over 70 per cent. Some pathologists regard all cases of pneumo-

TABLE II — LESIONS SIMULATING PNEUMOCONIOSIS

(IN THE ROENTGENOGRAMS)

- 1 Incipient Type  
Passive congestion of the lungs (cardiac)  
Acute respiratory tract infections  
Asthma
- 2 Interstitial Type  
Passive congestion of the lungs (cardiac)  
Acute and chronic respiratory infections (especially bronchitis and bronchiosinusitis)  
Polycythemia  
Metastatic malignancies, infiltrative type  
Mycoses  
Lymphoblastoma (infiltrative Hodgkin's)  
Pulmonary syphilis
- 3 Nodular Type  
Miliary tuberculosis  
Metastatic malignancies (miliary carcinosis)  
Periarthritis nodosa
- 4 Advanced Type  
Chronic pulmonary tuberculosis  
Pulmonary tumors  
Pulmonary syphilis

TABLE III — COMPLICATIONS OF PNEUMOCONIOSIS

(VISIBLE IN ROENTGENOGRAMS)

- Emphysema
- Limitation of diaphragmatic excursion
- Pleural thickening and effusion
- Pneumonia
- Bronchiectasis and cavitation
- Cardiac enlargement (right side)
- Cardiac failure
- Spontaneous pneumothorax
- Tuberculosis
- Chronic indurative pneumonia
- Bronchiogenic carcinoma

coniosis as being complicated by low-grade chronic pulmonary infection, and most cases as being complicated by low-grade or moderate tuberculosis. Agreement is far from complete on this important question. Riddell (14) has recently observed that "clinically, if not pathologically, forms of silicosis occur in which it is impossible by clinical means to demonstrate an infectious element (*i.e.*, simple silicosis)." On the other hand, it is well to note Gardner's opinion (4) that "silicosis differs from most other forms of pneumoconiosis in that it specifically predisposes to infection with the tubercle bacillus, at least 75 per cent of patients with silicosis die of tuberculosis, which may make its appearance at any stage of the disease. Silico-tuberculosis is sometimes rapidly fatal, sometimes very chronic."

# THE TREATMENT OF CARCINOMA OF THE BREAST BY EXTIRPATION OF THE TUMOR AND ROENTGEN IRRADIATION

(PRELIMINARY RESULTS)

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**H**IRSCH (1), of the Jewish Hospital of Berlin, reported, in 1927, on the results of tumor extirpation followed by radium treatment in cases of carcinoma of the breast. Of 22 cases, 21 were living, clinically well, and symptom-free after three years, 17 (77 per cent) after five years, and about the same number from six to thirteen years. That these outstanding results, in spite of the fact that they were confirmed by Halberstaedter (2), produced no noteworthy change in the methods of treating breast cancer is evidence of the difficulty with which a well established method of treatment may be changed. One of the contributory factors may well be the fact that radium therapy at that time was more exclusively confined to a few institutions than it is at present.

Our cases were treated exclusively by roentgen rays. Roentgen therapy has an advantage over radium therapy in that it may be almost universally carried out, and that usually during treatment the hospitalization of the patient is not necessary.

The greater portion of our 26 cases were operated on by Dozent Dr W Goldschmidt, Primararzt of the Surgical Division of the Hospital of the Isrealitischen Kultusgemeinde, and a former assistant in the Surgical Clinic of Eiselberg in Vienna. Goldschmidt deserves much credit for following out this method for the past ten years, and in view of the results he has obtained by it, even in those cases in which a radical operation seemed to be the method of choice, he has more and more often advised against the radical method of treatment (3).

Without going into greater detail let



Fig 1 The fields of irradiation

it be mentioned that, in those cases in which a tumor could be palpated in the breast and in which the axilla seemed clinically free of metastasis, only the tumor in the breast was removed. Also, the same procedure was followed in those cases in which only small axillary nodes could be palpated and when they did not seem to exceed the size of a pea. If a larger axillary tumor could be palpated, this together with the tumor in the breast was extirpated through a single incision. The basic idea in this procedure was to extirpate surgically all palpable disease and to take care of the microscopic phases by radiotherapy.

When we started treatment about ten years ago, cases in which the tumor alone had been extirpated were treated in just the same way as those in which a radical operation had been performed. We have

## SUMMARY

The extent, type, and location of the lesions of pneumoconiosis are always best demonstrated by roentgen examination, that is, by fluoroscopic study and stereoscopic postero-anterior and lateral roentgenograms

A classification of pneumoconiosis into four main types, based on the extent and the type of the lesions present, is a simplification of existing pathologic-roentgenologic classifications, and is more accurate than the still generally used three-stage classification

The roentgen findings only occasionally are pathognomonic of pneumoconiosis, however, linked with a clear history of exposure to silica-containing dust, they constitute the most valuable factor in diagnosis

The roentgen findings frequently do not parallel the subjective clinical findings, usually they are more marked than the latter, but in the rapid interstitial type of silicosis, they may be much less marked than one would expect from the symptoms

The roentgen examination is useful in deciding whether or not pneumoconiosis is complicated by pulmonary tuberculosis. It should be used in surveying applicants for employment in dusty industries (persons showing evidence of bronchosinusitis, asthma, pulmonary tuberculosis, and similar lesions being obviously undesirable for subjection to this potential health hazard)

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six instances Of the group of 12 cases which were treated with doses of from 3,000 to 6,000 r, distant metastasis occurred only once This difference is explainable if we keep in mind the fact that in the first group distant metastasis took place before local recurrence, a situation which was prevented by heavier radiation in the second group Therefore, we have a different set of conditions in our case from those in which radical operation has been done Whereas, in the cases in which radical operation has been carried out, distant metastasis occurs without local recurrence, in those cases in which only local excision of the tumor has been performed, distant metastasis takes place usually after local recurrence This course of events seems to justify the conception that in the extirpated cases the involvement of the blood stream by the recurrence leads to distant metastases, while in the cases radically operated on they take place as the result of the operative procedure itself Regarded from this point of view it seems as if simple extirpation of the tumor is to be preferred to radical operation, because not only does this procedure leave the breast intact, but also because the normal movements of the arm are preserved by not entering the axilla An outstanding advantage of this procedure seems to be that following extirpation it is possible to prevent distant metastasis to a far greater extent than after radical operation

The success which we have had in substituting simple removal of the tumor for radical operation seems largely to depend on the effect of post-operative radiation On it the value of the conservative operation stands or falls

Under these conditions the technic of roentgen irradiation is of special importance

From a radiotherapeutic point of view, the fact that recurrence (as has been mentioned) usually takes place in the operative scar or its immediate vicinity is of essential importance For this reason

we have in only the exceptional case, in which the tumor was below the nipple, treated the whole breast, in most cases the tumor is above the nipple, and for this reason in most cases we have treated the breast from the nipple to the anterior axillary line (Fig 1) This field receives, in from 8 to 14 days following operation, in 12 consecutive treatments each of about 300 r, a total dose of 3,600 r at 40 cm distance, 0.5 mm zinc filter, 170 kv Immediately afterward (or in those cases in which a severe reaction has occurred after an interval of from 8 to 14 days) treatment of the axilla is carried out in exactly the same way Treatment of the supraclavicular space to which on more or less theoretical grounds great importance has been assigned we abandoned several years ago both in the radical and the conservative group In our 26 cases in which there was no supraclavicular node present before operation, in not a single case did metastasis take place in spite of the omission of treatment of the supraclavicular space

Figures 2 and 3 illustrate the cosmetic results obtainable by the extirpation of the tumor followed by post-operative roentgen therapy in cases of carcinoma of the breast

In summary, we might state that a simple, safe method of irradiation has been found to be efficacious in preventing local recurrence in 80 per cent of the cases and distant metastasis during a minimal period of observation of one and one-half years The oldest case under consideration is of nine years' duration

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Fig 2 The right side operated on radically the left side conservatively



Fig 3 Patient had conservative operation in 1927 then post operative radiation. She has been symptom free since

described the technique of treatment elsewhere (4). Our practice was to repeat several series of treatments in the course of a year, the total dose varying between 1,000 and 2,500 r. We came to the conclusion that doses of this magnitude, averaging about 2,000 r, which usually prevented recurrence after radical operation, were insufficient to prevent recurrence if only the tumor had been extirpated. In a group of 11 cases which received total doses of from 1,000 to 2,500 r, recurrences took place in nine instances, these recurrences took place with these doses even in those cases which were given a single series. The time of recurrence is also of great interest, in approximately 80 per cent of the cases it took place within the first year, and in two cases, one and one-half years and two years after operation, respectively. Recurrence, which was most common in the operative scar or in its immediate vicinity, may be classified in two sub-groups. The larger of these, of six patients, later had distant metastases. After local recurrence, metastasis took place in some cases after a few months, and in others after from one to three years. In most of these cases metastasis took place in the skeleton, and in others in the lungs or brain. In one case the recurrence was removed operatively.

The second sub-group of three cases later became free of evidence of disease

Of two cases, the recurrence was treated by local removal in one and by radical operation in the other. Both types of operation followed intensive roentgen therapy.

From this sketchy outline of results we see that local recurrence definitely makes the prognosis worse, because in two-thirds of these cases distant metastasis takes place. Only a few of these cases could be salvaged, and in two the breast was preserved. The fact that recurrence did not follow excision may well be explained by the admission that a much higher dose was given than in the first course of post-operative treatment.

Even more outstanding is the effect of even greater doses if we keep in mind the results obtained by the administration of doses between 3,000 and 6,000 r. In a group of 12 cases treated in this way recurrence took place only once, while in the other group of 11 cases which were treated with lower doses it took place in about 80 per cent.

A comparison between the two groups is very instructive from another point of view. Of the group of 11 cases which were treated with doses of from 1,000 to 2,500 r, distant metastasis took place in



Fig 1

Fig 2

Fig 1 Case 1 Roentgenogram showing a greatly dilated stomach filling the abdomen

Fig 2 Case 1 Roentgenogram showing most of the large and small bowel in the left chest cavity

under apparently a surprisingly slight degree of trauma. In other cases, the presence of a hernia may not give rise to any symptoms whatever until some other factor such as indiscretion of diet, physical exercise, etc., brings to light vague symptoms which stimulate a general clinical study. We do not subscribe to the opinion expressed by some of the authors who recommend routine x-ray examinations to discover defects in the diaphragm before applicants engage in certain vocations. It must be remembered that a potential defect, which may yield only under sudden or gradual strain, is not possible to demonstrate by x-ray examination. If, however, evidence of herniation is found without symptoms, it should be regarded as a very definite potential danger, and the patient should be advised accordingly. A most interesting observation is made by Rigler in pregnant women

Out of 195 cases in the trimester, he found evidence of small herniation in 18.1 per cent of multipara and in 12.1 per cent for all cases. In seven positive cases, the evidence completely disappeared after parturition.

We are certain that many small defects in the diaphragm are completely overlooked or are very difficult to detect even by the most experienced, and probably many cases complaining of vague distress in the upper abdomen may be due to small undemonstrable ruptures. The symptoms which bring the patient to seek medical aid are not always clearly related to the herniation. In the series of cases under observation, the finding of diaphragmatic eventration apparently had little or nothing to do with the clinical picture. The true hernias, on the other hand, appeared to show more definite relation to the symptomatology. The

## EVENTRATION AND HERNIA OF THE DIAPHRAGM AS AN INCIDENTAL FINDING

By WILLIAM S. NEWCOMET, M.D., and EDGAR W. SPACKMAN, M.D. *Philadelphia*

CONSIDERABLE advance has been made during the last two decades in our knowledge of diaphragmatic lesions, and one of these, diaphragmatic hernia, is of especial interest to the internist, surgeon, and radiologist because in the majority of cases it is discovered by x-ray examination as an accidental finding during the course of a routine study. There is no single procedure which throws more sudden light on a vague or obscure clinical picture than the finding of a hernia through the diaphragm. Symptoms which are present vary widely, at times, they may be chiefly respiratory, cardiac, or gastro-intestinal, but at other times eventration or actual hernia is discovered in a person who has no complaint whatever. It is perfectly natural to suppose that the same general proportion of cases existed in the days before the x-ray was a recognized diagnostic method, but only a very few were reported in the earlier writings. The important point still remains that in the vast majority of cases the condition is not even suspected from the clinical point of view. Examinations were usually made for some other supposed condition which did not exist or during the course of routine study.

It is most important to know the position of the diaphragm in relation to the thoracic and abdominal organs and its motility. In the average person this offers no difficulty, but sometimes, due to overlapping of the diaphragmatic and visceral shadows, it is not definitely recognized on the radiographic film, and the motility is difficult to demonstrate fluoroscopically. The test of introducing gas into the stomach, either by means of a tube or effervescent powders, will not always settle the question of its relation to the diaphragm. This, however, is of considerable value since gas in the stomach will often demonstrate the overlying dia-

phragm with greater clarity, or show an increased degree of contrast in the herniated portion of the stomach above the level of the diaphragm. We wish to point out with especial emphasis the importance of gentle manipulation in several positions, watching the effect of the diaphragmatic motility on forced respiration and viewing the relation of diaphragm and abdominal viscera in various postures. By tilting the patient back in the Trendelenburg position to view the partially barium-filled stomach, a small hernia will often be detected projecting through the esophageal orifice which may not be recognized by any other procedure. It is always advisable to do the general fluoroscopy first in various postures before partially filling the stomach with gas, and to use the opaque meal last. It must, however, be borne in mind that there are hernias which do not contain the stomach and in these the difficulty of recognition is somewhat increased.

In Hedblom's report of 343 cases, 94 involved the stomach alone, 101, stomach and bowel, 86, bowel alone, and 62 were not classified. Some authors have attempted from statistical study to classify and explain the development of these hernias, but we believe it best to regard the diaphragm in the same manner as other muscular sheaths of the body. Thus, an individual may have a congenital weakness of the inguinal ring, but never suffer a true hernia, however, such a patient might be regarded as potentially liable to herniation. In a similar manner, it has been shown that there may be this potential weakness or unduly large opening at the esophageal orifice or about the crura, or there may be thinner places in the arch which are more liable to rupture than the remainder of the leaf. Judging from the clinical history, these congenitally weak areas may give way later in life.

and thin but well nourished Ever since a child, he had been subject to periodic stomach attacks These spells, usually relieved by vomiting (at one time amounting to six quarts) were often blamed upon some indiscretion in diet When the attacks became more frequent, he was referred for a gastro-intestinal examination, as a gastric ulcer or chronic appendix was suspected The clinical study of the chest was negative

A roentgenographic examination revealed that the abdominal cavity contained the stomach, which was unusually large, the duodenal cap being the size of a normal stomach, and the descending colon narrow, with a rather short sigmoid The small bowel and remainder of the colon were in the left chest with the appendix directly under the zyphoid The heart was pushed to the right, and very little of the left lung could be demonstrated A 24-hour study showed marked retention of barium in the stomach About a year later, an operation was performed and the diaphragm showed an opening extending from the spine outward about three inches and along the inner edge forward to the anterior chest wall, forming a triangle Beside the small intestine, the spleen was also above the diaphragm

#### COMMENT

It would appear evident that the hernia existed from early age, possibly being congenital, but as life progressed symptoms became worse, due to the gastric distress The hernia was not suspected, either from his clinical symptoms or physical examinations

Case 2 Female, colored, aged 45 years, suffered from a right-sided pain of three years' duration, obviously, from clinical and genito-urinary findings, due to a kidney lesion There was no history of accidents A physical examination pointed to the kidney but also revealed slight dullness to percussion over the left chest and distant breath sounds



Fig 5 Case 6 Herniation through the esophageal orifice which did not show in the upright position

An x-ray examination revealed an abnormal elevation of the left diaphragm, restriction of motion, and a high position of the stomach and splenic flexure The abdominal organs did not protrude through the diaphragm

The patient was admitted to the Jefferson Hospital and a nephrectomy was performed for hydronephrosis with extensive cortical drainage Her recovery was uneventful

#### COMMENT

The usual absence of symptoms with rather marked eventration of the left diaphragm is clearly shown An x-ray examination quickly cleared up the reason for physical findings, but the diaphragmatic condition was purely incidental

Case 3 A male, aged about 50 years, perfectly healthy, and about average build, was told, upon applying for more insurance, that he had some chest trouble He was referred to his family physician, who in turn advised an x-ray study (It is interesting to note that the same examiner for increased insurance had previously passed him)





Fig 3 Case 4 Upper pole of stomach visualized at the fifth interspace posteriorly. The heart is displaced to the right. A portion of the bowel also appears in the thoracic cavity.

symptoms in some cases were so varied and irregular that they were extremely misleading.

Grosser, in a report of 433 cases from autopsy material, stated that there could be demonstrated a probable congenital basis in 232. This proportion appears to be unusually high but as this study was made before the general use of x-ray, many acquired hernias were undoubtedly overlooked. Eventration is usually included in the general group but, strictly speaking, it should be in an entirely different category, this also applies to the rare cases of congenital absence or other anomalies. Eventration is not a rupture but may be regarded as stretching or relaxation, possibly due to a phrenic nerve injury which may occur as early as birth. The other outstanding congenital condition, shortening or incomplete development of the esophagus, has been fully discussed recently by Manges and Clerf.

Several authors have reported congenital right-sided hernias which are usually observed in young children. In most cases



Fig 4 Case 4 Note the apparent deformity in the lower portion of the stomach probably due to constriction (lateral view).

they were discovered at postmortem. Recently this condition has come to the attention of the radiologist through the reports of Kcrr and Steinberg.

In our service at the Presbyterian Hospital, Philadelphia, during the routine examination of 17,295 cases of chest and abdominal conditions, covering a period from 1922 to 1935, there were eight cases of interest from the standpoint of diaphragmatic lesion. Of these, two were undoubtedly congenital hernias (Cases 1 and 6), four could be classed as eventration (Cases 2, 3, 5, and 8), two were due to trauma (Cases 4 and 7), and of these, five were discovered without any outstanding clinical evidence (Cases 1, 2, 3, 5, and 8). Several cases were investigated for cardiac condition, some for vague indigestion or other upper abdominal distress, and a few were referred with a suspicion of the condition from clinical data. Brief summaries of the cases follow.

Case 1 Male, aged 19 years, a college student and on the track team, was tall

An x-ray examination showed the left diaphragm to be elevated. The heart and trachea were displaced to the right. The colon occupied a very high position.

The patient was treated in the nose and throat clinic and was later discharged.

#### COMMENT

The diaphragmatic finding was incidental, caused no discomfort, and was of interest only as a medical curiosity.

Case 6 Female, aged 64 years, complained of vague indigestion for four or five years, usually a half-hour after meals, severe in character, and arriving and leaving suddenly, with occasional attacks of nausea and vomiting. Her diet did not influence it. For the past six weeks, she had suffered dull epigastric distress (it became worse on exertion), insomnia, loss of 25 pounds in weight, and vomiting after nearly every meal.

A physical examination showed absolutely nothing of value. A tentative diagnosis of possible cholecystitis or gastric malignancy was made.

An x-ray examination, with the patient in the upright posture, showed an apparently normal diaphragm. In the supine posture, there was noted an indefinite protrusion of barium apparently through the esophageal orifice. In the Trendelenburg position, a large diaphragmatic hernia was demonstrated, the stomach very definitely riding above the level of the diaphragm.

An operation was advised but the patient refused and left the hospital unimproved.

#### COMMENT

A case of true diaphragmatic hernia without apparent cause, probably due to congenital weakness which developed late in life.

Case 7 A male, was admitted to the University Hospital in 1927 following an accident, as the result of which he received fractures of the femur, radius, and pelvis,



Fig 8 Case 8 Roentgenogram, showing a high diaphragm and colon filled with barium enema.

with extensive third degree burns. No diagnosis was made of any chest or diaphragm pathology at that time.

In 1931 he complained of vague symptoms. An x-ray examination showed the left diaphragm to be high, at the level of the fifth posterior interspace, and immobile. The right diaphragm was freely movable. The stomach was very high, it was not definitely shown to project above the level of the diaphragm.

He was operated upon at the University Hospital, the result of which revealed a traumatic rupture of the diaphragm, with a hernia of the abdominal viscera, and a large ulcer of the stomach. The diaphragm was torn loose from its intercostal attachments so that it had barged up against the median part. At the point of the impingement upon the edge of the diaphragm some twenty feet of small intestine were extracted from the left pleural cavity, as well as the transverse and descending colon and spleen. In pulling the stomach down, the ulcer which



Fig 6

Fig 6 Case 7 Left diaphragm is elevated and immobile The heart is pushed to the right Parts of the stomach, bowels and spleen are found in the left chest cavity



Fig 7

Fig 7 Case 3 The left diaphragm is elevated The left lung is partially compressed The heart is displaced to the right Cases 2 and 5 showed practically the same picture with only a slight variation of the amount of displacement

The x-ray examination revealed a very high diaphragm on the left side The whole stomach was above the normal position

#### COMMENT

The cause and onset of the elevation of the diaphragm remain obscure

Case 4 Colored boy, aged 19 years, was injured in an automobile accident just previous to admission He was thrown forward, violently striking his upper left abdomen against the steering wheel The jolt did not render the patient unconscious, but he vomited repeatedly and had violent hiccoughs On physical examination, the left upper abdomen was rigid, and there was marked tenderness over the area of contusion No masses were palpable, nor were there signs in the chest except restriction of movement The heart was slightly displaced to the right, and questionable dullness was present over the lower left lobe to percussion laterally His intra-abdominal injury was diagnosed as a possible rupture of the spleen or diaphragm

X-ray examination revealed a dilated

and deformed stomach, very high in position, and partly in the left chest cavity The heart was displaced to the right The left lung was somewhat compressed from the organs of the abdomen which had penetrated the left diaphragm

Operation showed a tear of the diaphragm 6 cm in length, running forward and toward the left from the esophageal opening The omentum, transverse colon, and stomach were herniated This was easily reduced, the laceration sutured, and the patient discharged shortly afterward, symptom-free

#### COMMENT

Obviously a case of the acquired type, traumatic, and one of the few in which any evidence of the condition was present

Case 5 Male, aged about 40 years, was referred from the out-patient department for a routine chest x-ray examination because of hoarseness The patient had had a sudden onset of three weeks' duration There was no other complaint

A physical examination revealed râles in the lower right chest anteriorly, and questionable dullness in the right apex No physical signs were reported over the left lung-field

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had no stomach wall but had a base of thin peritoneum, was pulled loose. In spite of every precaution he developed peritonitis and died.

#### COMMENT

It is quite evident that symptoms of hernia did not exist previous to the injury. They developed gradually later, becoming worse but not severe enough to attract attention until four years had lapsed, when he was not able to carry on his daily vocation. It seems perfectly logical to presume that the injury was the cause of the hernia, which became worse until the operation was indicated. However, there may have been some weakness of the diaphragm previous to the accident.

Case 8. Colored female, aged 39 years, complained of general abdominal pain of eight months' duration. She had suffered from severe constipation and vague indigestion for many years previously.

A physical examination showed slight dullness over the left chest laterally, from the seventh rib to the base, which was thought to be due to fluid or thickening pleura. A pelvic examination showed old inflammatory disease.

An x-ray examination revealed that the splenic flexure and left diaphragm were visible at the level of the seventh rib posteriorly. There was total fixation of the left diaphragm.

#### COMMENT

Pelvic operation was performed with no complication. The upper abdomen was not explored.

#### DISCUSSION

Some authorities believe that diaphragmatic hernias are fairly common and that many are simply overlooked by inexperienced operators. It has been our practice to carefully explore the diaphragm in all examinations made of the chest or gastro-intestinal system, and with this in view, only four cases were observed in 17,295, or about one in every 4,324 cases.

If those of eventration are considered, it would be one in every 2,160. In other words, the condition will be found only occasionally in the ordinary x-ray laboratory. It will also be noted that these cases of eventration have been symptomless, and in no way do they appear to inconvenience the individual, even when subjected to severe abdominal operations.

A hernia, however, is a serious matter and the symptoms are apt to be progressive; they are rather mild at the onset and become more exaggerated as time advances. The result of any operative procedure will depend entirely upon the amount of viscera displaced into the cavity of the chest, the length of time between the onset and the operation, and the character of the adhesions to the different structures.

The amount of embarrassment to respiration and the circulation is usually surprisingly small even in the severe cases. The shock following the operation, and danger of infection are much more grave and must be taken into consideration.

No spontaneous cure was registered, but it would seem possible that it might occur under such circumstances as reported by Rigler. Although a number of pregnant women were examined, hernia was not found, nor were simple irregularities simulating hernias included in the list.

#### CONCLUSION

Most of the papers upon this subject agree that the discovery of diaphragmatic hernia, during life, is by x-ray examinations, usually made to ascertain the cause of some unusual symptoms. The number and class of cases coming under observation depend largely upon the character of the clinic and explain the wide difference of opinion in these reports.

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cast and the inclusion of uncertain amounts of scattered radiation from both test sample and lead echelon. Successive exposures on the same or different films are

and filters under test. By decreasing the solid angle subtended by the entrance diaphragm of the ionization chamber, and by sufficiently increasing the distance be-

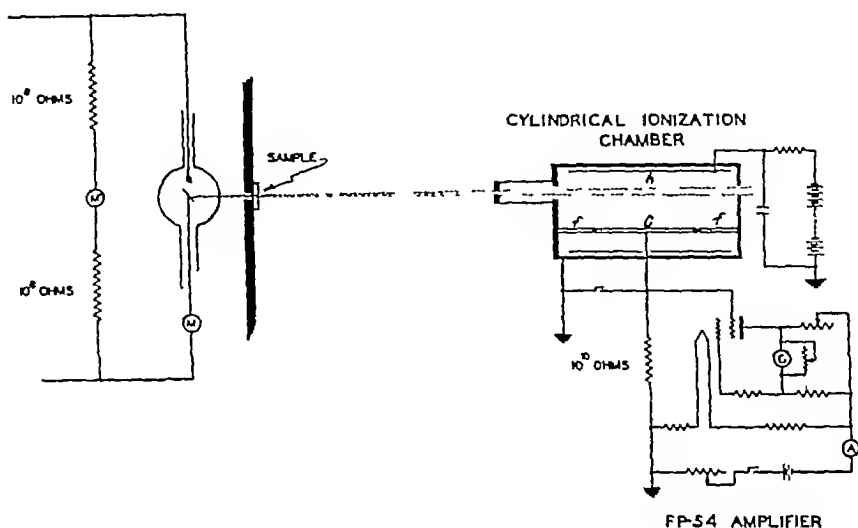


Fig 1 Diagram of the apparatus used in determining the lead equivalent of a protective material

also undesirable, for obvious reasons. That  $\gamma$ -rad filter which gives directly or by interpolation the same photographic density as the sample is taken to be the lead equivalent of the sample. From this the protection coefficient is calculated.

The ionization method consists in comparing the current in a suitable x-ray ionization chamber obtained by using the sample as filter with the currents similarly obtained using a series of graduated lead filters. That thickness of lead which would give the same ionization current as the glass sample is then taken to be the lead equivalent of the sample.

Of these two methods, the photographic is more commonly used, since it requires a less elaborate experimental set-up. Its chief advantage is that, unlike the ionization method, a constant source of x-rays is not essential, since the exposure of both the glass sample and the standard lead echelon are made simultaneously. With the ionization method the geometrical constants of the system used in making the measurements can be adjusted so as to minimize the effect of x-ray scattering from the glass

between the sample under test and the chamber, thus scattering can be made negligible. These adjustments are not possible with the photographic method, and consequently the protection coefficient so obtained usually differs from that obtained by the ionization method.

The result from the photographic method differs from that of the ionization method in that the former registers not only the transmitted radiation but in addition the secondary radiation from the material. Although it is true that from the point of view of protection, there is no need to distinguish between transmitted and scattered radiation from a protective material, it is desirable to separate the two factors, absorption and scattering. Unless this is done, a reproducible measure of the lead equivalent or protection coefficient of a material is more or less doubtful. Moreover, since the secondary radiation from glass has a different spectral composition than that of metallic lead, it is questionable whether two such different radiations can be satisfactorily compared by photographic means. Little is known concerning the variation

# ABSORPTION OF X-RAYS BY LEAD GLASSES AND LEAD BARIUM GLASSES<sup>1</sup>

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## ABSTRACT

THE results of a study of the protective properties of a group of typical flint and barium-flint glasses are reported. In chemical composition, the protective glasses analyzed were found to resemble closely the denser optical flint and barium-flint glasses. The protection coefficients of the glasses were determined by an ionization method, of the various component elements it was found that only lead and barium contribute appreciably to the protective effectiveness of the glasses.

For flint glass empirical relations were established between the protection coefficient and the chemical composition, density, and refractivity, for barium-flint glass an empirical relation is given between the protection coefficient and the lead-oxide and barium-oxide components of the glass.

## I INTRODUCTION

Gorton,<sup>2</sup> Dorsey,<sup>3</sup> and Kaye and Owen<sup>4</sup> have examined the x-ray protective properties of heavy flint glasses, and have correlated the protection coefficients<sup>5</sup> of these

<sup>1</sup> Research Paper RP870, Part of Journal of Research of the National Bureau of Standards March, 1936, 16

<sup>2</sup> W S Gorton, Am Jour Roentgenol, October, 1918, 5

<sup>3</sup> N Ernest Dorsey, Am Jour Roentgenol, March 1919

<sup>4</sup> Kaye and Owen, Proc Phys Soc, London, 1923, 35, 33D

<sup>5</sup> "Protection coefficient" has been defined by the American Advisory Committee on X ray and Radium Protection as follows

"The protection coefficient of a protective material is the ratio of the thickness of lead to the thickness of material which absorbs a given x-ray beam to the same extent

It is to be noted that the absorption coefficient of a material is a measure of its opacity to x rays of a given quality as compared with that of metallic lead, and therefore, depends not only upon the absorption properties of the material itself but upon those of lead as well. It is not a measure of the absolute opacity of the material

glasses with the glass density. However, in recent years x-ray flint glasses have been largely supplanted by x-ray barium-flint glasses which, from the point of view of protection, are essentially different. Our tests of x-ray glasses have shown that the findings of the earlier studies (References 2, 3, and 4) are not directly applicable to the newer x-ray glasses without considerable extension and modification. This is principally because barium is of lower density and lower atomic number, and, hence, has absorption properties differing from those of metallic lead. The objects of the present study of x-ray glasses were

1 To obtain the protection coefficient of flint and barium-flint glasses as a function of x-ray quality

2 To correlate the protection coefficient with such readily determined physical properties of glass as density and refractive index

3 To determine the relation between the protection coefficient of the glass and its chemical composition

## II METHODS OF DETERMINING THE PROTECTION COEFFICIENT OF A MATERIAL

The relative x-ray opacities of materials are usually determined by either a photographic or an ionization method. Inasmuch as these two methods do not always give results which are in good agreement, and this fact is not usually appreciated, a brief discussion of them will be given.

The photographic method consists in simultaneously radiographing a glass sample and a lead echelon consisting of a prepared series of lead filters. This is usually done by placing the sample and echelon side by side directly upon the cassette containing the photographic film, and exposing them to radiation. It is desirable to reduce the distance between the radiographed material and photographic film to a minimum so as to avoid overlapping of the shadows

of a galvanometer having a current sensitivity of  $5.7 \times 10^{-9}$  ampere per millimeter and a period of 3 seconds. The over-all sensitivity of the system is  $7.4 \times 10^{-15}$

given deflection can be read. A more serious cause of uncertainty in the galvanometer zero is the irregular displacement current produced in the ionization chamber

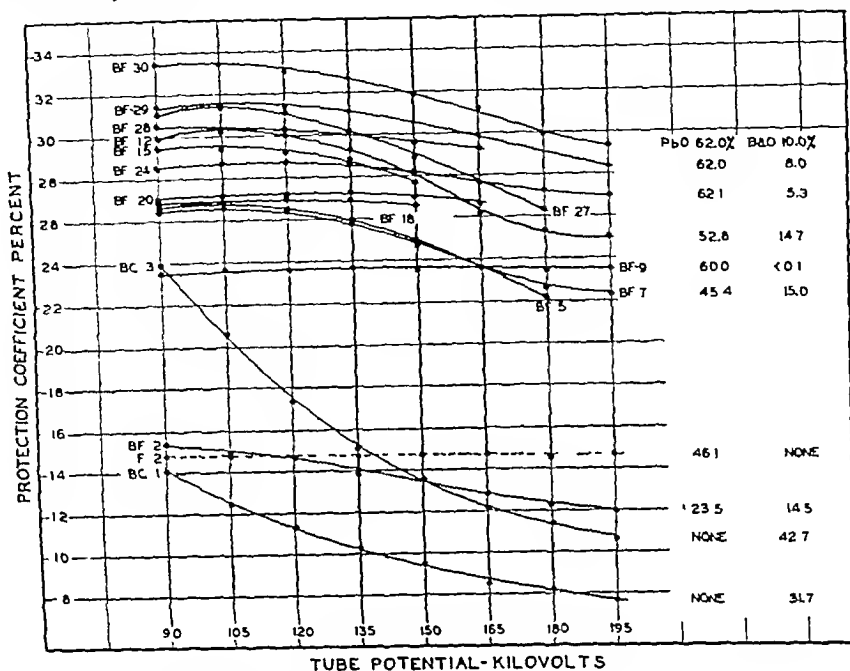


Fig. 3 The variation of the protection coefficient of barium-flint and barium crown glass with x-ray tube potential

ampere per millimeter and the current amplification is  $7.7 \times 10^5$ . Under these conditions the stability of the galvanometer zero is satisfactory, the observed zero drift being no greater than 1 mm per hour from 30 to 60 minutes after closing the amplifier battery circuit. However, under the working conditions where the electrodes of the ionization chamber are charged two conditions combine to produce an unsteady zero. The first is a short period fluctuation of from 1 to 2 mm resulting from random bursts of ionization caused by alpha particles originating in traces of radio-active impurities<sup>8,9</sup> in the electrodes, and from radio-active contamination of the free air within the chamber. Because of their short period these fluctuations are readily distinguished from those resulting from variations in the x-ray input to the ionization chamber, and therefore they do not seriously affect the accuracy with which a

by random fluctuations in the potential difference between the electrodes arising from variations in the emf of the high voltage supply. The inter-electrode capacity of the chamber used is only 53  $\mu\text{f}$ , but a sudden variation of 0.1 volt in the potential difference produces a displacement current which registers a deflection of 30 mm at full sensitivity. Since 1,000 volts are required for saturation, it is evident that an extremely constant high voltage supply is essential. Large B batteries in good condition are satisfactory.

The ionization current was measured by direct deflection. Inasmuch as ionization readings for both metallic lead and for glass are here directly compared any variation from linear amplification<sup>10</sup> in this system does not affect the results.

<sup>10</sup> The ratio between output current and input current for the system used varies from a straight line by approximately 1 per cent for deflections up to the maximum obtained. Where strictly linear amplification is essential it is necessary to operate the electrometer tube on a fixed point of its plate current-grid

<sup>8</sup> J. A. Bearden, *Rev. Sci. Instr.* 1933, 4, 271

<sup>9</sup> Ziegert, *Ztschr. f. Phys.*, 1927, 46, 668



in photographic sensitivity with  $\gamma$ -ray quality, and in the absence of definite information on this point, it is unsafe to as-

resulting from random fluctuations in the potential difference between the high potential electrode and ground

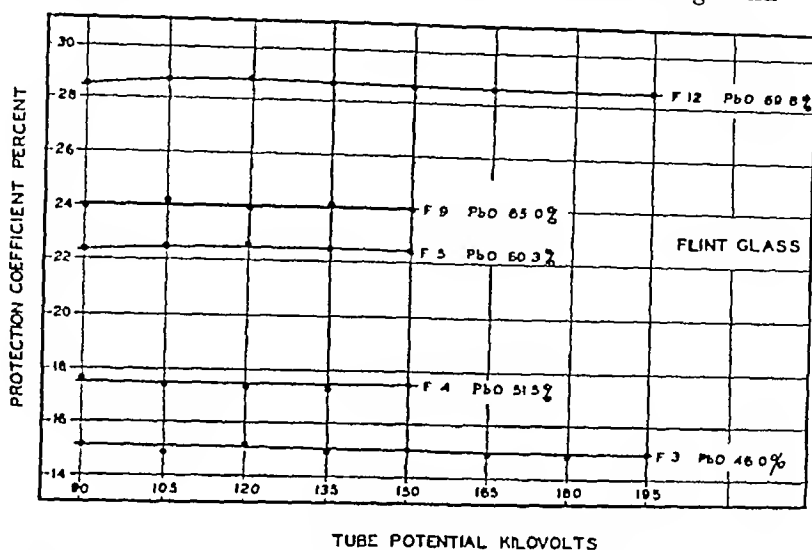


Fig 2 The variation of the protection coefficient of flint glass with  $\gamma$  ray tube potential

sume that the sensitivity of the emulsion used is not a function of wave length <sup>6</sup>

### III EXPERIMENTAL PROCEDURE

The ionization method and experimental arrangement sketched in Figure 1 were used here. For measuring the relative absorption properties of materials the cylindrical ionization chamber is better suited than is the parallel-plate ionization chamber commonly used in dosage standardization. The  $\gamma$ -ray intensities which must be measured in opacity tests are necessarily very low, for most of those here reported the radiation intensity after filtration is about  $10^{-4}$  times that of the incident radiation. It is desirable to have the volume of air ionized large enough to furnish ionization currents that are not troublesomely small. However, an increase in this volume augments at the same time the inter-electrode capacity and the collector-to-ground capacity of the system, and the effect of both is to increase the period of the system and to produce an uncertain galvanometer zero because of induced currents

The ionization chamber used is of the cylindrical open-air type. It consists of a thin aluminum cylinder electrode (*h*) spaced by hard rubber posts from a concentric supporting brass tube 30 cm in diameter and 60 cm long, closed at the ends with aluminum. The edges of this electrode are somewhat rounded and separated several centimeters from the ends of the supporting cylinder so as to minimize field distortion. The collector electrode is a brass cylinder (*c*) about 1 cm in diameter and 30 cm long. Guard cylinders (*f*) of the same diameter extend to the earthed ends of the chamber. The chamber is covered with one-eighth inch of lead throughout, with an additional one-eighth inch thickness on the front face.

The distance from the middle of the collector electrode to the tube target is 147 cm, and from the middle of the collector to the sample 74 cm.

The ionization current is measured by means of a balanced<sup>7</sup> direct current amplifier, using an F P -54 electrometer tube. The amplifier output is measured by means

<sup>6</sup> R. B. Wilsey, *Am Jour Roentgenol and Rad Ther*, 1935, 32, 789

<sup>7</sup> Lee A. DuBridge and Hart Brown, *Rev Sci. Inst* 1933 4, 532

For the purpose of comparison, eight standard optical glasses were included, six of these were obtained from the Glass Section of this Bureau

Although lead and barium are the effective components of protective glasses, it is convenient in considering the protective properties of these glasses to consider the protection coefficient as a function of the oxides of these metals rather than of the metals themselves

In Tables I and II there are listed all flint

and barium-flint x-ray glasses studied, together with such of their chemical and physical properties as are of interest in connection with this study<sup>13</sup> The classification of each glass is given in column 2 BC-1, BC-2, and BC-3 of Table II are optical barium crown glasses, not used for x-ray protection, but included here for pur-

<sup>13</sup> We are indebted to J I Hoffman for checking the chemical analyses of the glasses listed, to L W Tilton for all refractivity measurements, and to E L Peffer for all density determinations

TABLE I—LIST OF FLINT GLASSES

Glass	Classification	No Samples of Each Glass	Refractive Index $n_D$	Density	PbO	BaO	Protection Coefficient (Per Cent) for—						
							90 kv	105 kv	120 kv	135 kv	150 kv	165 kv	195 kv
F-1 <sup>a</sup>	Commercial x-rays	2	1 618	3 609	46 1	0 0	14 96	14 93	15 06	14 94	15 11	14 84	14 72
F-3 <sup>b</sup>	Optical flint	1	1 622	3 630	46 0	0 0	15 13	14 96	15 17	14 90	15 03	14 88	14 94
F-4 <sup>b</sup>	Optical flint	1	1 647	3 859	51 6	0 0	17 84	17 43	17 53	17 49	17 55	17 35	17 25
F-5 <sup>a</sup>	Commercial x-rays	2	1 700	4 310	60 3	0 0	22 30	22 43	22 51	22 43	22 32	22 60	22 51
F 9 <sup>a</sup>	Commercial x-rays	1	1 721	4 479	65 0	0 0	23 92	24 20	23 99	24 13	23 99		
F-12 <sup>b</sup>	Optical flint	1	1 775	4 932	69 8	0 0	28 42	28 66	28 77	28 66	28 62	28 52	28 50

<sup>a</sup> Chemical analyses submitted by manufacturer

<sup>b</sup> Batch analyses submitted by Mr Finn of NBS Glass Section

<sup>c</sup> Chemical analysis made by Mr Hoffman of NBS Chemistry Division

TABLE II—LIST OF BARIUM-FLINT AND BARIUM CROWN GLASSES

Glass	Classification	No Samples of Each Glass	Refractive Index $n_D$	Density	PbO	BaO	Protection Coefficient (Per Cent) for—						
							90 kv	105 kv	120 kv	135 kv	150 kv	165 kv	195 kv
BF-1 <sup>a</sup>	Optical barium flint	1		3 392	6 87	29 15						9 89	8 89
BF-2 <sup>b</sup>	Optical barium flint	1	1 603	3 479	23 5	14 5	15 35	14 86	14 62	13 79	13 58	12 75	11 93
BF-3 <sup>a</sup>	Commercial x ray	2	1 614	3 572	44 1	< 1	14 80	14 78	14 81	14 66	14 74	14 81	14 72
BF-5 <sup>c</sup>		2	1 6949	4 323	47 1	14 35	26 43	26 56	26 31	25 76	24 65		21 56
BF-7 <sup>a</sup>		2	1 6992	4 361	45 38	15 02	26 60	26 90	26 46	25 96	24 93	23 57	22 26
BF-9 <sup>c</sup>		3	1 7146	4 423	60 0	< 1	23 49	23 63	23 58	23 64	23 48		23 43
BF-12 <sup>c</sup>		2	1 723	4 587	52 0	13 94	29 42	29 38	29 14	28 61	27 70		
BF-14 <sup>a</sup>		1	4 604	53 15	13 01	29 98	29 74	29 22	28 80	27 73	26 17	24 90	
BF 15 <sup>a</sup>		2	1 7254	4 609	52 6	14 7	29 88	30 15	29 83	29 27	28 20	26 05	25 02
BF-17 <sup>a</sup>		1	4 609	51 2	15 5		29 7				28 0		
BF-18 <sup>c</sup>		2	1 741	4 690	62 2	2 34	28 88	26 88	26 94	26 90	26 57		
BF-20 <sup>c</sup>		1	1 742	4 698	61 6	2 52	27 01	27 11	27 17	27 24	26 99	26 63	26 41
BF 22 <sup>a</sup>		2	1 7306	4 712	60 9	6 5	28 43	28 62	28 64	28 54	27 91	27 54	26 81
BF-24 <sup>a</sup>		2	1 7428	4 734	62 1	5 3	28 27	28 69	28 49	28 42	27 85	27 63	27 08
BF 27 <sup>a,d</sup>		1	4 837	52 6	14 6	31 02	31 30	31 09	30 22	28 80	28 09	26 23	
BF-28 <sup>a,e</sup>		1	4 886	62 0	5 3	30 50	30 29	30 27	30 19	29 60	29 29	28 25	
BF-29 <sup>a</sup>		1	4 906	62 0	8 0	31 37	31 30	31 30	31 01	30 14	29 83	28 44	
BF-30 <sup>a</sup>		1	5 055	62 0	10 0	33 38	33 39	32 97	31 67	31 69	31 16	29 25	
BF-31 <sup>a</sup>		1		61 0	9 7		32 0		30 6			28 4	
BC 1 <sup>b</sup>	Optical barium crown	1	1 572	3 205	0 0	31 7	14 03	12 41	11 28	10 23	9 45	8 45	7 62
BC-2 <sup>a</sup>		1	3 513	0 0	38 40							10 04	8 71
BC-3 <sup>b</sup>		1	1 606	3 701	0 0	42 7	23 94	20 60	17 31	14 95	13 52	12 05	10 56

<sup>a</sup> Chemical analyses submitted by manufacturer

<sup>b</sup> Batch analyses submitted by Mr Finn of NBS Glass Section

<sup>c</sup> Chemical analyses made by Mr Hoffman of NBS Chemistry Division

<sup>d</sup> Glass BF 27 contains 5 per cent of  $TiO_2$

<sup>e</sup> Glass BF-28 contains 2 per cent of  $UO_2$

X-rays were generated by means of a thick wall therapy x-ray tube supplied with power by a 200-kv constant potential generator previously described<sup>11</sup> The

IV DESCRIPTION OF GLASSES

Commercial x-ray protective glasses now available are of two kinds

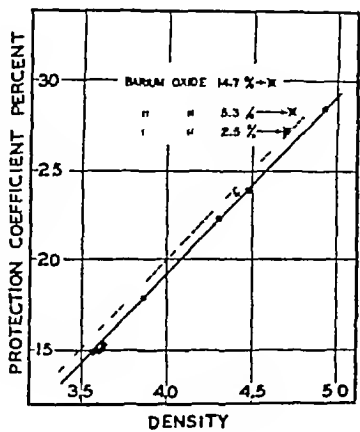
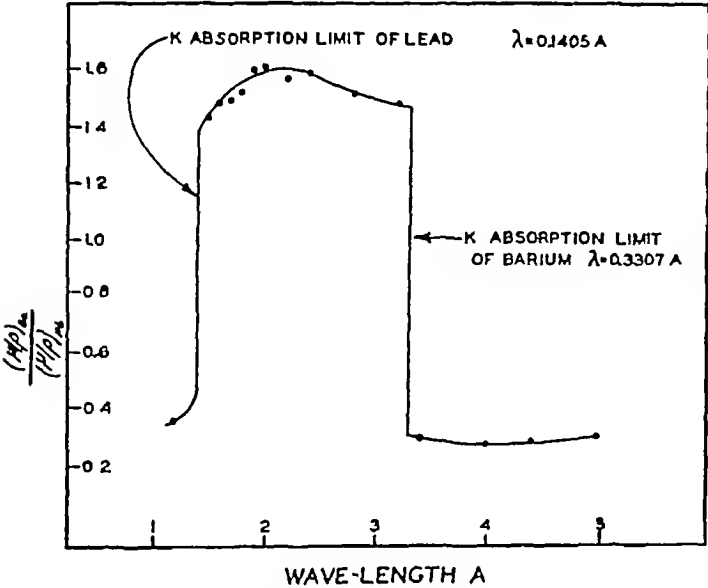


Fig 4 The ratio of the mass absorption coefficients of barium and lead as a function of the effective wave length of a narrow spectral band of x radiation  
Fig 5 The protection coefficient of flint glass as a function of the glass density

power supply input is stabilized, variations in power input being not greater than  $\pm 0.3$  per cent. The cathode of the x-ray tube was heated by storage batteries. Both tube voltage and current were continuously observed and controlled by the operator from his station near the amplifier. It is estimated that variations in x-ray input to the ionization chamber did not exceed  $\pm 0.5$  per cent. When the x-ray generator is manually controlled these variations are reduced to approximately  $\pm 0.25$  per cent. The potential difference across the x-ray tube was read directly by means of an accurately calibrated, high resistance voltmeter<sup>12</sup> consisting of a microammeter in series with two resistance units of 100 megohms each.

potential characteristic. This is best done by the introduction of a potentiometer in the grid circuit, and the use of the system as a null instrument.

<sup>11</sup> L. S. Taylor, Bureau of Standards Jour. Research 1929, 2, 771, RP56  
<sup>12</sup> L. S. Taylor, Bureau of Standards Jour. Research 1930, 5, 809, RP217

1 Dense flint glasses whose x-ray protective qualities are practically determined by their lead content alone.

2 Barium-flint glasses whose effectiveness arises from the presence of both lead and barium.

Other constituents of both types of x-ray glasses are of comparatively low atomic number and hence do not contribute much to the protective qualities of these materials. The recent trend in x-ray glasses has been toward those of higher protection coefficient, that is, from the flint to the barium-flint glasses. Although the former are now relatively unimportant commercially as a protective product, they are here of interest as a means of understanding the newer barium-flint x-ray glasses.

This report is based on a study of 30 glasses obtained from a number of different sources. Of these, 22 are commercial x-ray glasses selected from a group of 53 as being representative of protective x-ray glasses commercially available at the present time.

the same PbO component. The protection coefficient of the latter glass does not vary appreciably with voltage and is readily determined from any one of several physical and chemical properties of the glass.

## VI PROTECTION COEFFICIENT OF GLASS FOR A NARROW SPECTRAL BAND OF RADIATION

### 1 Flint Glass

In order to understand the characteristic differences between  $\gamma$ -ray glasses of the flint and barium-flint types described in the preceding section, it is convenient to set up equations for the protection coefficient of a glass as a function of the absorption coefficients of its component elements. To do so, it is necessary to make assumptions concerning experimental conditions which in practice cannot be rigorously fulfilled. These assumptions are

1 That the radiation for which the coefficient is defined is homogeneous in frequency

2 That the filters used are so thin and the  $\gamma$ -ray beam so collimated that all incident rays traverse equal thicknesses of filter

3 That the filter thickness is so small that the effective wave length of the radiation is not appreciably altered by filtration when the radiation used is not strictly homogeneous with respect to frequency

The first of these conditions is never fulfilled,  $\gamma$ -ray glasses are intended primarily for protection against heterogeneous radiation, and tests are made using such radiation. However, as is already evident from Figure 2 and the discussion of the preceding section, the wave length effect is very small for flint glasses and it may, therefore, be expected, as is indeed the case, that for such glasses the protection coefficient calculated for a narrow spectral band of radiation is a satisfactory approximation of the experimentally determined value for heterogeneous radiation. For barium-flint glasses the case is, however, quite different since there is considerable variation in protection coefficient with variation in radiation quality. Consequently the protection co-

efficient for barium-flint glasses calculated for a narrow spectral band is difficult to interpret and is not directly comparable with the experimental value. However, even for barium-flint glasses the equations derived for a narrow spectral band of  $\gamma$ -rays are valuable in that they reveal the relation whereby the protection coefficient changes with variation in radiation quality.

The second assumed condition can be approximated in practice, as has here been done, by diaphragming the beam so that for all rays there is little difference in path-length through the filter.

The glass filters used were approximately one-fourth inch thick. Since filters of such thickness harden the incident heterogeneous radiation considerably, the further assumption is involved that the quality changes resulting from filtration through the corresponding thickness of metallic lead and through glass are identical.

Let a beam of a narrow spectral band of radiation of intensity  $I_0$ , be reduced to intensity  $I$ , on traversing a glass sample of thickness  $X_{gl}$ . Now let a filter of metallic lead be selected of such thickness,  $X_{pb}$ , that it, also, will reduce the intensity of the  $\gamma$ -ray beam from  $I_0$  to  $I$ . Then

$$I = I_0 e^{-\mu_{gl} X_{gl}} = I_0 e^{-\mu_{pb} X_{pb}}, \quad (1)$$

where  $\mu_{gl}$  and  $\mu_{pb}$  are respectively the linear-absorption coefficients of the glass sample and the metallic lead filter for the  $\gamma$ -radiation in question. From Equation 1 and the definition of the protection coefficient ( $C$ ),<sup>15</sup> it follows that

$$C = \frac{X_{pb}}{X_{gl}} = \frac{\mu_{gl}}{\mu_{pb}} = \frac{\mu_{gl}}{(\mu/\rho)_{pb} \rho_{pb}}, \quad (2)$$

where  $(\mu/\rho)_{pb}$  is the mass absorption coefficient for lead for the  $\gamma$ -radiation in question, and  $\rho_{pb} = 11.34$  is the density of lead. Since the mass absorption coefficient of an element is essentially independent of its physical or chemical state,<sup>16</sup> it is possible to express the linear absorption coefficients of the glass sample,  $\mu_{gl}$ , in terms of the mass absorption coefficients of its several

<sup>15</sup> See Footnote 5

<sup>16</sup> See for example, Int. Crit. Tables, 1929, 6, 12

poses of comparison. The chemical analyses given for PbO and BaO content were obtained mostly from the glass manufacturers. In several cases our measurements of the opacity to  $\gamma$ -rays indicated that the manufacturer's analysis must be in error. In each of these a chemical analysis made by Mr. Hoffman at this Bureau confirmed our views, and for these Mr. Hoffman's analyses are recorded instead of those given by the manufacturer.

It should be noted that the commercial  $\gamma$ -ray glasses of both the flint and barium-flint types are very similar in their chemical and physical properties to the typical optical glasses of these types. The  $\gamma$ -ray glasses are different only in that their content of lead and barium oxide is, in general, greater.

#### V PROTECTION COEFFICIENT AND QUALITY OF RADIATION

The manner in which the protection coefficient of a glass depends upon the quality of the incident  $\gamma$ -radiation is of particular interest. If there is a marked variation in the protection coefficient of a glass as the  $\gamma$ -ray quality is varied, the coefficient determined for any one quality may be quite adequate for calculating the glass thickness required to meet  $\gamma$ -ray safety recommendations<sup>14</sup> for that particular radiation but may be dangerously inadequate for a corresponding calculation for radiation of another quality. In such a case it is obviously meaningless to speak, as is often done, of the protection coefficient or lead equivalent of the glass unless the quality of radiation for which the coefficient applies is also specified.

The protection coefficient of a flint glass, which depends for its protective quality almost wholly on its lead content, is, in general, independent of the radiation quality. This is apparent from Figure 2 in which the protection coefficient of the glasses listed in Table I is plotted as a function of the excitation potential on the  $\gamma$ -ray tube. Here the locus of the protection coefficient of any one flint glass is nearly a horizontal straight

line. For most glasses of this type there appears to be a very slight, though negligible, maximum at about 105 kv, which is probably due to the light oxide components of the glass.

As shown in Figure 3, the protection coefficient of a barium-flint glass, in contrast with that of a flint glass, is not independent of radiation quality. The protection coefficient here yields a curve with a maximum at about 105 kv, irrespective of the amount of barium present. The accentuation of the maximum increases, however, with the increase of barium content, glasses containing relatively large quantities of BaO having the most marked maxima. For barium crown glasses, such as BC-1 and BC-3, the variation of protective coefficient with radiation quality is most marked. The maxima for these glasses are not shown since they lie below the tube-voltage ranges used.

A comparison between the protection coefficient of a flint and a barium-flint glass containing the same percentage of PbO is of interest in that effectiveness of the BaO component of the barium-flint glass then becomes apparent. In order to facilitate such a comparison, the protection coefficient curve of a flint glass, F-2, having about the same PbO content as barium-flint BF-7, has been included in Figure 3. Although this is a typical case, other examples are available between glasses listed in Tables I and II. Comparing curves, F-2 and BF-7 reveals that the protection coefficient of a barium-flint glass is considerably greater than that of a flint glass containing the same percentage of PbO. This difference is especially marked in the vicinity of the maximum for 105-kv  $\gamma$ -rays, but with increasing hardness of the radiation the difference in coefficients diminishes.

It is obvious that the protection coefficient of a barium-flint glass cannot be less than that of a flint glass containing the same percentage of PbO. This point is of practical interest, since it defines the lower limit of the protection coefficient of a barium-flint glass in terms of the protection coefficient of a flint glass containing-

<sup>14</sup> Bureau of Standards Handbook 15, 1931.

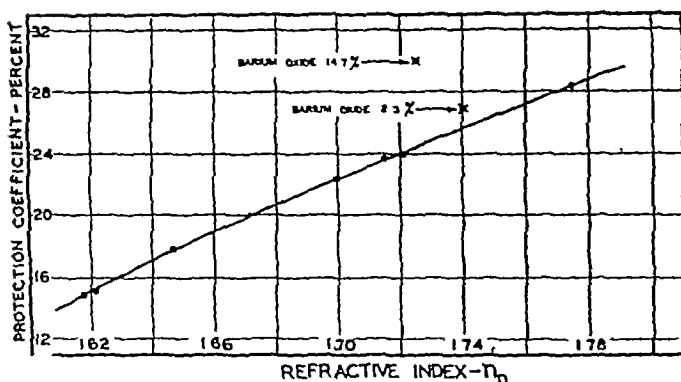


Fig 6

Fig 6 The protection coefficient of flint glass as a function of the refractive index of the glass

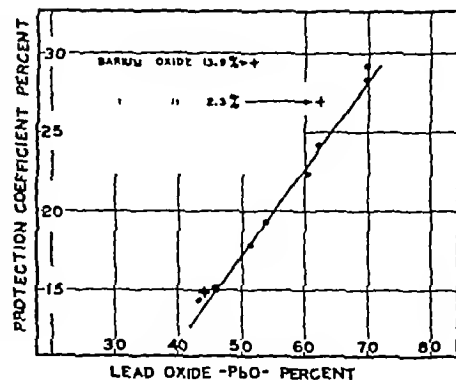


Fig 7

Fig 7 The protection coefficient of flint glass as a function of the percentage of lead oxide (PbO) contained in the glass

If it is, therefore, assumed that for heavy flint glass the effect on the coefficient of all elements other than lead is negligible, Equation 5 can be simplified by dropping the second term, which gives

$$C = \frac{\rho_{gl}}{\rho_{Pb}} P_{Pb} \quad (6)$$

Equation 6 then gives an approximation for the protection coefficient of a heavy flint glass simply in terms of the percentage of lead it contains, the glass density, and the density of lead. Since the density of lead is 11.34 and that of heavy flint glass about 4, it follows that for such glasses the protection coefficient is roughly equal numerically to one-third the percentage of lead contained. The statement is occasionally made that a flint glass containing, say, 60 per cent of lead will have a protection coefficient of 60 per cent, but this is not to be expected from Equation 6, and that it is not true is evident from any one of the curves given in Figure 2. By means of Equation 5 the chief characteristics of flint glass as a protective material (as found experimentally) can be explained, namely

1 The protection coefficient of a flint glass is practically independent of radiation quality

2 All elements contained in a flint glass other than lead contribute little to the value of the glass as a protective material

## 2 Barium-flint Glass

It has already been noted in connection with the discussion of Figure 3 that a barium-flint glass has an appreciably greater protection coefficient than a flint glass containing the same percentage of lead oxide. This is to be expected since the atomic number of barium (56) is considerably greater than that of most elements found in glass, however, the marked protective effectiveness of barium for heterogeneous radiation of about 105 kv cannot be attributed to this cause alone. It is convenient to rewrite Equation 5 for a barium-flint glass as follows

$$C = \frac{\rho_{gl}}{\rho_{Pb}} P_{Pb} + \frac{\rho_{gl}}{\rho_{Pb}} \left( P_{Ba} \frac{(\mu/\rho)_{Ba}}{(\mu/\rho)_{Pb}} \right) + \frac{\rho_{gl}}{\rho_{Pb}} \sum \frac{(\mu/\rho)_i}{(\mu/\rho)_{Pb}} \quad (7)$$

where  $P_{Ba}$  is the fraction of total mass of glass which is barium, having a mass absorption coefficient  $(\mu/\rho)_{Ba}$ . Since the percentage of the light elements (those other than barium and lead) in an x-ray barium-flint glass is less than that in a flint glass containing the same percentage of lead, it is to be expected that the contribution toward the protection coefficient made by the lighter components is even less in a barium-flint than in a flint glass having the same percentage of lead. If we, therefore, assume the effect of the elements other than lead and barium to be negligible, Equation 7 becomes

$$C = \frac{\rho_{gl}}{\rho_{Pb}} \left( P_{Pb} + P_{Ba} \frac{(\mu/\rho)_{Ba}}{(\mu/\rho)_{Pb}} \right) \quad (8)$$

component elements,  $(\mu/\rho)_1$ ,  $(\mu/\rho)_2$ , etc., as follows

$$\mu_{\text{el}} = \rho_{\text{el}} [P_1(\mu/\rho)_1 + P_2(\mu/\rho)_2 + \dots + P_n(\mu/\rho)_n] \quad (3)$$

where  $P_1$ ,  $P_2$ ,  $P_3$ , etc., are the ratios of the mass of each component to the total mass of the glass,  $(\mu/\rho)_1$ ,  $(\mu/\rho)_2$ , etc., are the mass absorption coefficients of these components, and  $\rho_{\text{el}}$  is the glass density. Equation 2 then becomes

$$C = \frac{\rho_{\text{el}}}{\rho_{\text{Pb}}} \left[ P_1 \frac{(\mu/\rho)_1}{(\mu/\rho)_{\text{Pb}}} + P_2 \frac{(\mu/\rho)_2}{(\mu/\rho)_{\text{Pb}}} + \dots + P_n \frac{(\mu/\rho)_n}{(\mu/\rho)_{\text{Pb}}} \right] \quad (4)$$

Since lead is the most important component in all protective x-ray glasses, it is convenient to rewrite Equation 4 as follows

$$C = \frac{\rho_{\text{el}}}{\rho_{\text{Pb}}} P_{\text{Pb}} + \frac{\rho_{\text{el}}}{\rho_{\text{Pb}}} \left[ P_2 \frac{(\mu/\rho)_2}{(\mu/\rho)_{\text{Pb}}} + P_3 \frac{(\mu/\rho)_3}{(\mu/\rho)_{\text{Pb}}} + \dots + P_n \frac{(\mu/\rho)_n}{(\mu/\rho)_{\text{Pb}}} \right] \quad (5)$$

By means of Equation 5 it is possible to calculate the protection coefficient  $C$  of any glass for a narrow spectral beam of radiation, having given the composition and density of the glass and the mass absorption coefficient of each component element for that radiation. The total protection coefficient  $C$  is expressed as the sum of two quantities. The first of these gives the component of the total coefficient due to the metallic lead contained in the glass, the second is the component of the total coefficient due to the presence of all component elements other than lead. The first right-hand term involves no quantity which varies with the quality of the incident radiation, the second involves the mass absorption coefficient of metallic lead and

of each element contained in the glass, all of which are functions of radiation quality. It is, therefore, to be expected that the protection coefficient of any glass is independent of radiation quality only to the extent that the component of the total protection coefficient due to elements other than lead is negligibly small as compared with that due to the lead content of the glass.

That the component of the total protection coefficient due to elements other than lead is small for flint glass is evident from Table III. Here the protection coefficients of four flint glasses as calculated by means of Equation 5 for wave lengths 0.098 and 0.710 Å are compared with the experimentally determined values for 90 and 150 kv. The calculated coefficients given in columns 3 and 4 are lower than the experimentally determined values of columns 5 and 6. The agreement, however, becomes satisfactory for the denser flint glasses. It should be noted that glasses F-3 and F-4 are optical flint glasses, which are lighter than most x-ray glasses of this type. They are included here because it was desired to test the validity of Equation 5 for glasses lying immediately outside the range of typical x-ray glasses. Glass F-5 is a typical x-ray flint. Glass F-12 is a very dense optical flint, heavier than any x-ray flint tested. In columns 6 and 7 of Table III there is given for each glass the fraction of the calculated protection coefficient due to glass components other than metallic lead. For the dense flint glasses the total contribution of all elements other than lead is small, being of the order of 2 or 3 per cent.

TABLE III—PROTECTION COEFFICIENTS OF FOUR TYPICAL FLINT GLASSES AS CALCULATED BY EQUATION 5 COMPARED WITH EXPERIMENTALLY DETERMINED VALUES

1	2	3	4	5	6	7	8
Glass	PbO  <i>Per Cent</i>	Protection Coefficient (Per Cent)				Fraction of Total Calculated Coefficient Due to Components of Glass Other than Lead for	
		Calculated for*		Observed for		$\lambda = 0.098 \text{ Å}$	$\lambda = 0.710 \text{ Å}$
		$\lambda = 0.098 \text{ Å}$	$\lambda = 0.710 \text{ Å}$	150 kv	90 kv		
F-3	46.0	14.5	14.3	15.0	15.1	0.055	0.044
F-4	51.5	17.1	16.9	17.6	17.8	0.046	0.036
F-5	60.3	22.1	21.8	22.3	22.3	0.035	0.026
F-12	69.8	28.6	28.6	28.6	28.4	0.012	0.014

\* The mass absorption coefficients used in these calculations were taken from data tabulated by Compton and Allison, X-rays in Theory and Practice, p. 800. D. Van Nostrand Co. Inc. New York, 1935.

particularly noticeable in barium crown glasses, such as BC-1 and BC-3 of Figure 3

## VII EMPIRICAL RELATIONS FOR PROTECTION COEFFICIENT OF FLINT GLASS

As already noted, the theoretical relations derived for the protection coefficient of glass are limited in their practical usefulness by the simplifying assumptions necessary for their derivation, the most formidable of which is the assumption that the  $\gamma$ -radiation is homogeneous. Because of these limitations, empirical relations between the protection coefficient and such properties of the glass as density, refractive index, and lead-oxide and barium-oxide content are desirable. Then, when any one of these properties is known, it may be possible to predict the protection coefficient of a typical  $\gamma$ -ray protective glass from these empirical relations without actually determining the protection coefficient experimentally. The values so obtained agree with the accurately determined experimental value to within a few per cent and are usually as good as the experimental value obtainable with the apparatus and equipment in the average x-ray laboratory.

It is comparatively easy to find empirical relations for a typical  $\gamma$ -ray glass which contains only PbO as an effective component, for a barium-flint  $\gamma$ -ray glass the problem is complicated by the presence of an additional component, BaO.

### 1 Protection Coefficient and Density

The relation between the protection coefficient and the density of a flint glass is given in Figure 5 for typical  $\gamma$ -ray glasses ranging in density from 3.61 to 4.93. Over this range, the protection coefficient is found to be a linear function of the glass density, given by the equation

$$C = 10\rho_{gl} - 20.8, \quad 3.61 < \rho_{gl} < 4.93 \quad (9)$$

where again  $C$  is the protection coefficient and  $\rho_{gl}$  the glass density. This is in substantial agreement with a similar equation by Kaye,<sup>17</sup> derived from a study of flint glasses ranging in density from 3.2 to 4.8.

<sup>17</sup> G. W. C. Kaye, *Roentgenology*, p. 89. Paul B. Hoeber Inc. New York, 1929.

Equation 9, based on data obtained here for 90-kv radiation, holds, within the experimental error, for radiations up to 195 kv. The values for  $C$  so obtained are about 3 per cent lower than Kaye's. The effect of a small barium-oxide component may be noted from the points plotted also in Figure 5 for glasses containing small quantities of barium oxide.

### 2 Protection Coefficient and Refractive Index

In Figure 6 the protection coefficient of each flint glass studied has been plotted against the refractive index of the glass obtained for the D line of sodium. The effect of a small barium component in increasing the protection coefficient is again apparent. Inasmuch as the refractive index of a glass is readily determined, the curve of Figure 6 is a very convenient means for determining the protection coefficient of a flint glass.

### 3 Protection Coefficient and Chemical Composition

Figure 2 indicates that in general the protection coefficient of a flint glass depends upon the PbO contained in the glass and increases as this component is increased. Figure 7 shows the more exact nature of this dependence, as made evident by replotting the same data with the protection coefficient as ordinate and the PbO content of the glass as abscissa. The closed circles represent experimental data obtained for flint glasses listed in Table II. The open circles are points obtained by means of Equation 9 from Wright's<sup>18</sup> collected data on the relation between the density and the PbO content of optical flint glasses. The crossed circles are for  $\gamma$ -ray glasses containing small amounts of BaO. It appears that the protection coefficient of a flint glass is an increasing function of the percentage of lead oxide. This function is not exactly linear but for a PbO component ranging from 46 to 70 per cent, it can be satisfactorily approximated by the straight line equation

<sup>18</sup> The Manufacture of Optical Glass and of Optical Systems, p. 60. Ordnance Dept. Document 2037 (U. S. Government Printing Office, Washington, D. C., 1921).



From this, it is evident that the protection coefficient of a barium-flint glass must depend upon the quality of the incident radiation since the mass absorption coefficients

increased. As the tube voltage is increased further, the critical absorption limit of lead is reached at which the absorption coefficient of lead is approximately doubled

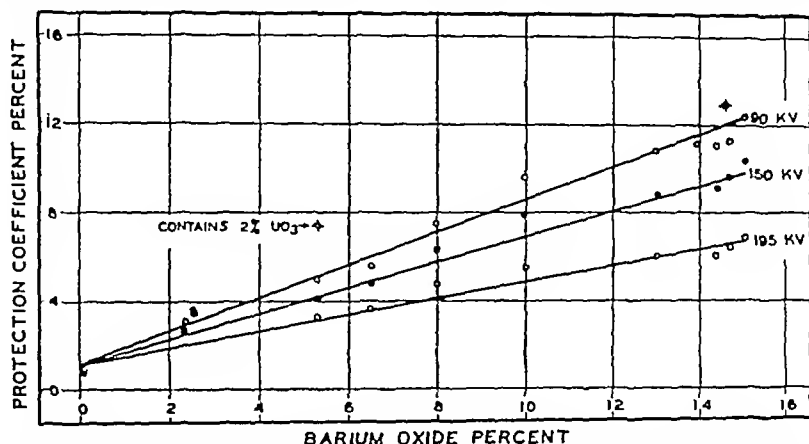


Fig 8 The component of the total protection coefficient of barium flint glass due to all elements of the glass other than lead plotted as a function of the percentage of barium oxide ( $\text{BaO}$ ) contained in the glass

of both lead and barium are involved, both of which are functions of wave length, moreover, the wave length effect must vary with the percentage of barium ( $P_{\text{Ba}}$ ) contained in the glass, as has already been noted in connection with the experimentally determined value. The nature of this dependence is evident from a consideration of the manner in which the mass absorption coefficient of an element varies with effective wave length of a narrow spectral beam. At the critical absorption limits of both lead and barium, there are discontinuities in their respective absorption coefficients, and since these discontinuities occur at different wave lengths, it is evident that there must be distinct discontinuities in the protection coefficient of a glass containing barium. Of particular interest are the discontinuities of these elements at their respective K absorption limits, which, for lead, occur at  $0.1405 \text{ \AA}$  and for barium at  $0.3307 \text{ \AA}$ . As the x-ray tube voltage is increased, the K absorption limits of barium are approached from the long wave length side, and at this limit the mass absorption coefficient of barium is increased about sixfold. The composite protection coefficient as given by Equation 8 will, therefore, be correspondingly in-

creased. For radiation of this quality, the protection coefficient will, therefore, be decreased since the mass absorption coefficient of lead occurs in the denominator of Equation 8. As a result of these discontinuities the protection coefficient of a glass containing barium should have a maximum value in the interval  $0.1405 \text{ \AA} < \lambda > 0.3307 \text{ \AA}$ . In Figure 4 the ratio of the mass absorption coefficient of barium to that of lead has been plotted as a function of wave length for a narrow spectral band of radiation.

For heterogeneous radiation, no distinct discontinuities in the protection coefficient, such as shown in Figure 4, are to be expected. However, since any heterogeneous beam having a minimum wave length less than  $0.1405 \text{ \AA}$  has some radiation lying in the above-mentioned interval, the effect of the barium component in the glass is to increase the protection coefficient. The actual increase depends upon what fraction of the total energy of the composite beam falls within the interval  $0.1405 \text{ \AA} < \lambda > 0.3307 \text{ \AA}$ . As the x-ray-tube voltage is increased above 105 kv less and less of the total energy of the beam falls within this interval and the protection coefficient is correspondingly decreased, as has already been noted from the experimental data. This effect is

Further study of the relation between this increase in protection coefficient with the BaO component of the glass reveals that for radiation of a given quality, the amount by which the coefficient is increased is approximately a linear function of the BaO component and, as is to be expected, is essentially independent of the PbO component. In Figure 8 the amount by which the protection coefficient of a barium-flint glass exceeds that of a flint glass containing the same percentage of PbO, has been plotted as a function of the BaO component of the barium-flint for three different tube voltages, 90, 150, and 195 kv. The points of Figure 8 show considerable scattering arising from the extent to which components other than PbO and BaO contribute appreciably to the total protection coefficient of the glass. However, for x-ray barium flints this scattering is no greater than 3 per cent of the total protection coefficient of the glass. One exception is to be noted, an "experimental" x-ray glass containing 2 per cent of  $\text{UO}_3$  (uranium trioxide), in this case the heavy oxide had been included in order to test the effect of heavy oxides other than those of lead and barium. From the data plotted in Figure 8, the following relations have been obtained

$$\text{For 90 kv } C_{\text{BaO}} = 0.727P_{\text{BaO}} + 1.2 \quad (11)$$

$$\text{For 150 kv } C_{\text{BaO}} = 0.586P_{\text{BaO}} + 1.0 \quad (12)$$

$$\text{Where } 0 < P_{\text{BaO}} < 15$$

where  $P_{\text{BaO}}$  is the percentage of barium oxide in the barium flint, and  $C_{\text{BaO}}$  is the amount by which the protection coefficient of a barium flint exceeds that of a flint containing the same percentage of lead oxide.

## 2 Protection Coefficient and Chemical Composition

By adding Equations 10 and 11 an expression is obtained for the protection co-

efficient of a barium-flint glass for 90-kv x-rays in terms of the barium-oxide and lead-oxide components of the glass

$$C = 0.553P_{\text{PbO}} + 0.727P_{\text{BaO}} - 9.3 \quad (13)$$

$$\text{Where } \begin{cases} 46 < P_{\text{PbO}} < 70 \\ 0 < P_{\text{BaO}} < 15 \end{cases}$$

The corresponding equation for 150-kv x-rays is obtained by the addition of Equations 10 and 12,

$$C = 0.553 + 0.586P_{\text{BaO}} - 9.5 \quad (14)$$

$$\text{Where } \begin{cases} 46 < P_{\text{PbO}} < 70 \\ 0 < P_{\text{BaO}} < 15 \end{cases}$$

Equations 13 and 14 are based on observations of flint glasses approximately 6 mm thick. Kaye<sup>19</sup> has reported that for radiation of a given quality the lead equivalent of barium-sulphate plaster is not strictly proportional to the thickness of the material. He found that the departure from the linear relationship between lead equivalent and thickness increases with the x-ray voltage and is quite marked for 200-kv x-rays. Equations 13 and 14 have been tested for glasses up to 10.0 mm in thickness and have been found satisfactory. However, it should not be assumed that these equations are valid for glasses varying very much from the thickness for which they were derived.

In Table V, the experimentally determined protection coefficients for 90- and 150-kv x-rays of all barium-flint glasses studied are compared with the coefficients calculated by means of the empirical Equations 13 and 14.

The writer acknowledges the co-operation, assistance, and advice of Lauriston S. Taylor, under whose supervision this work was done.

<sup>19</sup> G. W. C. Kaye, *Roentgenology*, p. 93. Paul B. Hoeber, Inc. New York, 1929.

$$C = 0.553(P_{\text{PbO}} - 19), \quad 46 < P_{\text{PbO}} < 70, \quad (10)$$

where  $P_{\text{PbO}}$  is the per cent of PbO contained in the glass. X-ray glasses commercially available fall well within the range of PbO components for which this linear approximation is satisfactory.

In Table IV the experimentally determined protection coefficients for 90- and 150-kv x-rays of all flint glasses studied are compared with the coefficient calculated by means of Equation 10.

#### VIII EMPIRICAL RELATIONS FOR BARIUM-FLINT GLASS

##### 1 Effect of Added Barium Oxide on Protection Coefficient

That there is a marked increase in the protection coefficient of an x-ray glass when BaO is added has already been noted in the discussion of Figure 3. Some idea of the effectiveness of even a very small BaO component in an x-ray glass can be obtained from Figure 7 in which, for 90-kv radiation, the two points with crosses are for glasses containing 2.3 and 13.9 per cent of BaO in addition to their PbO component. It is apparent that for radiation of this quality, as little as 0.5 per cent of BaO results in an appreciable increase in the protection coefficient of the glass. For more penetrating radiation the effect of the BaO component is less, but is still appreciable.

TABLE IV—FLINT GLASSES

Glass	Classification	PbO %	Protection Coefficient (Per Cent) for—			
			90 kv		150 kv	
			Experimental	Calculated	Experimental	Calculated
F-1	Commercial x ray	46.1	15.0	15.0	15.1	15.0
F-3	Optical flint	46.0	15.1	14.9	15.0	14.9
F-4		51.5	17.8	18.0	17.6	18.0
F-5	Commercial x ray	60.3	22.3	22.8	22.3	22.8
F-9		65.0	23.9	25.4	24.0	25.4
F-12	Optical flint	69.8	28.4	28.1	28.6	28.1

TABLE V—EXPERIMENTAL VALUE OF PROTECTION COEFFICIENT OF BARIUM-FLINT GLASSES COMPARED WITH VALUES CALCULATED BY MEANS OF EQUATIONS 13 AND 14

Glass	PbO %	BaO %	Protection Coefficient (Per Cent) for—			
			90 kv		150 kv	
			Experimental	Calculated	Experimental	Calculated
BF-1 <sup>a</sup>	6.87	29.15		15.7		11.4
BF-2 <sup>a</sup>	23.5	14.5	15.3	14.2	13.6	12.0
BF-3 <sup>a</sup>	44.1	< 1	14.8	15.1	14.7	14.0
BF-5	47.1	14.35	26.4	27.2	24.6	25.0
BF-7	45.38	15.02	26.6	26.7	24.7	24.4
BF-9	60.0	< 1	23.4	24.0	23.5	23.7
BF-12	52.0	13.94	29.4	29.6	27.7	27.4
BF-14	53.15	13.01	30.0	29.6	27.7	27.5
BF-15	52.6	14.7	29.9	30.5	28.2	28.2
BF-17	51.2	15.50	29.7	30.3	28.0	27.9
BF-18	62.6	2.34	27.0	27.0	26.5	26.5
BF-20	61.6	2.52	27.0	26.6	27.0	26.0
BF-22	60.9	6.5	28.3	29.1	28.0	28.0
BF-24	62.1	5.3	28.4	28.9	28.0	28.0
BF-26	61.24	5.50	28.7	28.0	28.1	27.6
BF-27 <sup>b</sup>	52.6	14.6	31.0	30.4	28.8	28.1
BF-28 <sup>c</sup>	62.0	5.3	30.5	28.8	29.6	27.9
BF-29	62.0	8.0	31.4	30.2	31.7	29.5
BF-30	62.0	10.0	33.4	32.3	31.7	30.7
BF-31	61.0	9.7			30.6	29.9

<sup>a</sup> Equations 13 and 14 do not strictly apply here since the percentage of lead oxide (PbO) in these glasses is less than 46 per cent.

<sup>b</sup> Glass BF-27 is an experimental x ray glass containing 5 per cent of TiO<sub>2</sub>.

<sup>c</sup> Glass BF-28 is an experimental x ray glass containing 2 per cent of UO<sub>2</sub>.

Further study of the relation between this increase in protection coefficient with the BaO component of the glass reveals that for radiation of a given quality, the amount by which the coefficient is increased is approximately a linear function of the BaO component and, as is to be expected, is essentially independent of the PbO component. In Figure 8 the amount by which the protection coefficient of a barium-flint glass exceeds that of a flint glass containing the same percentage of PbO, has been plotted as a function of the BaO component of the barium-flint for three different tube voltages, 90, 150, and 195 kv. The points of Figure 8 show considerable scattering arising from the extent to which components other than PbO and BaO contribute appreciably to the total protection coefficient of the glass. However, for x-ray barium flints this scattering is no greater than 3 per cent of the total protection coefficient of the glass. One exception is to be noted, an "experimental" x-ray glass containing 2 per cent of  $\text{UO}_3$  (uranium trioxide), in this case the heavy oxide had been included in order to test the effect of heavy oxides other than those of lead and barium. From the data plotted in Figure 8, the following relations have been obtained

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BF-12	52.0	13.94	29.4	29.6	27.7	27.4
BF-14	53.15	13.01	30.0	29.6	27.7	27.5
BF-15	52.6	14.7	29.9	30.5	28.2	28.2
BF-17	51.2	15.50	29.7	30.3	28.0	27.9
BF-18	62.6	2.34	27.0	27.0	26.5	26.5
BF-20	61.6	2.52	27.0	26.6	27.0	26.0
BF-22	60.9	6.5	28.3	29.1	28.0	28.0
BF-24	62.1	5.3	28.4	28.9	28.0	28.0
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<sup>c</sup> Glass BF-28 is an experimental x-ray glass containing 2 per cent of UO<sub>2</sub>.



Fig 2



Fig 3

Figs 2 and 3 Same patient Radiographic examination of the esophagus and stomach shows no evidence of obstruction in any portion of the esophagus There is at present no irregularity in contour such as might suggest the presence of a neoplasm at the cardiac end of the esophagus or stomach

#### SURGERY

Achievements of radical surgery in carcinoma of the esophagus are reported by Torek and Eggers, in the United States, and more recently by Tudor Edwards and G Grey Turner, in England. However, the technical difficulties of the operation are so great, the disease so well established when first diagnosed, and the condition of the patient so poor, that only in exceptional cases can any kind of success be hoped for. However, palliative surgery, gastrostomy in selected cases, is often indicated for the relief of obstruction and for feeding purposes to stave off starvation. The rest given to the esophagus often relieves the pain due to the associated inflammatory congestion.

#### TREATMENT BY RADIATION

Reports of the complete regression of histologically proven epidermoid carcinoma of the esophagus by radiation methods have been reported in the literature. Guisez, using radium in tube or bougie form and inserting it into the lumen of the esophagus, has reported good palliative results in a large series of cases. By this method he was able to obtain freedom from symptoms in some cases for 11, 10, and 5 years. Holfelder had the opportunity to do post-mortem examination of a 65-year-old patient with epidermoid carcinoma of the esophagus, who died five months after protracted roentgen therapy of bronchopneumonia. The esophagus was completely healed, with smooth walls, a linear scar

# ESOPHAGEAL-GASTRIC CARCINOMA SUCCESSFULLY TREATED BY PROTRACTED FRACTIONAL X-RAY

(SIX-YEAR SURVIVAL)

By SAMUEL M. BAUM, M.D., *New York City*

From the Radiation Therapy Department, Beth Israel Hospital, Director, Dr. I. Seth Hirsch

## INTRODUCTION

CARCINOMA of the esophagus constitutes from 2 to 5 per cent of all cases of malignant disease.

It has been shown statistically (Hoffman) that cancer of the esophagus is far from being a rare disease. At the present time it is responsible for over two thousand deaths per annum. The death rate from this disease has increased from 1.0 per hundred thousand in 1915, to 1.7, in 1932, in the United States Registration Area. The rate for males is much higher than that for females. In England and Wales, in 1931, it was 9.09 per hundred thousand for men and 2.99 for women.

Of 37 cases of esophageal cancer seen from 1929 to 1935, 27 were males and 10 females. Its greatest incidence occurs between the ages of 50 and 60 years.

## ANATOMIC LOCATION

The most frequent site of predilection is the thoracic portion of the esophagus, then the cardiac, and the least frequent is the cervical portion.

## PATHOLOGIC TYPES

There are several pathologic types: (1) The bulky, polypoid tumors which extend into the lumen of the esophagus causing early obstructive symptoms, (2) The shallow ulcerating type, causing early symptoms of mediastinal involvement with clinical signs of pain and backache, although metastases and obstructive symptoms may be absent, (3) The infiltrating scirrhous type which invades the esophageal wall, encircling the lumen, and producing fixation of the walls with marked obstruction.

## DIAGNOSTIC METHODS

Radiologic examination with the aid of



Fig. 1. There is marked dilatation of the lower end of the esophagus just above the diaphragm. Beyond is a carcinoma of the esophagus and cardiac end of the stomach.

the opaque barium mixtures will show the site of the growth, its extent, and degree of obstruction. It will at the same time exclude other conditions simulating carcinoma.

Esophagoscopy will reveal the pathologic type of growth, and the anatomic location of the tumor. The instrumental examination gives the opportunity to investigate the amount of patency of the lumen and opportunity for removal of a portion of the growth for histologic examination.

The most frequent histologic structure is that of epidermoid carcinoma, acanthoma. Hornification or pearl formation is not common. Broders finds the majority of the tumors to fall into Grade III and IV, which would make them fairly radiosensitive.

of the middle and lower third. Beyond this the mucous membrane was found infiltrated and thrown into folds, slightly beyond this was found a tumor mass, arising from the anterior wall of the esophagus, which partially occluded the esophageal lumen. A piece of tissue was removed for microscopic study. The tumor was quite vascular and a free flow of blood followed the removal of the biopsy specimen.

The microscopic findings of the small fragments removed (Path No 17,395) revealed a squamous-cell carcinoma with hornification. The stroma was edematous and there was secondary infiltration of leukocytes and lymphocytes.

Other laboratory findings were as follows: urine, essentially negative, blood, red blood cells, 3,800,000, hemoglobin, 62 per cent, white blood cells, 15,500, polymorphonuclears, 72 per cent, mononuclears, 28 per cent, Wassermann, negative, blood chemistry, glucose, 125 mgm, non-protein-nitrogen, 40.

#### TREATMENT

High voltage x-ray therapy, the protracted fractional method, was immediately instituted following the establishment of a definite diagnosis of squamous-cell carcinoma. It was felt that a gastrostomy was not indicated as the patient was able to take liquid nourishment and retain it.

The technical factors were 200 kv, 4 ma, 70 cm distance. Filtration was through 2 mm Cu and 1 mm Al. Large portals averaged 400 sq cm. Daily treatments were given. Cross-firing of the lower esophagus and cardiac end of the stomach was done through upper abdominal and right and left oblique portals, each portal receiving about 5,000 r units. Forty-two treatments were given over a period of 69 days, the average dose per treatment being 480 r units. Each portal was given the maximum skin toleration until a radio-epidermitis resulted.

Early in the course of treatment, which was effective from the beginning, the patient began to show improvement in swallowing. After a month of treatment he



Fig 6 Photomicrograph  $\times 300$ , from same case

was able to take solid food. The localized pain had diminished, the patient felt generally better and showed a tendency to gain weight. Soon after the completion of the treatment the patient was able to take all solid foods. He had no substernal pain or pain when swallowing. The radiographic examination at that time showed only a slight degree of irregularity at the cardiac end of the esophagus, corresponding to the site of the original lesion.

The patient has been seen and examined in the follow-up clinic for the last six years. When seen on March 29, 1936, his weight was 170 pounds, a gain of 26 pounds since treatment. Blood examination showed red blood cells, 5,000,000, hemoglobin, 80 per cent, white blood cells, 5,000. The patient has been carrying on his usual occupation for the last four years, and is able to eat everything with no pain. The fluoroscopic and radiographic examinations show no evidence of obstruction in any portion of the esophagus.

#### RESUME

The possible reason for success in the treatment of our case may be due to limited localized involvement, the relative radiosensitivity of the growth, and the





Fig 4

Fig 4 Photomicrograph  $\times 100$  Biopsy from esophageal tumor through bronchoscope *Squamous cell carcinoma* There are many tumor cells with very large nuclei. The stroma of the carcinoma is partly edematous. Parts of the tumor are infiltrated with leukocytes and lymphocytes.

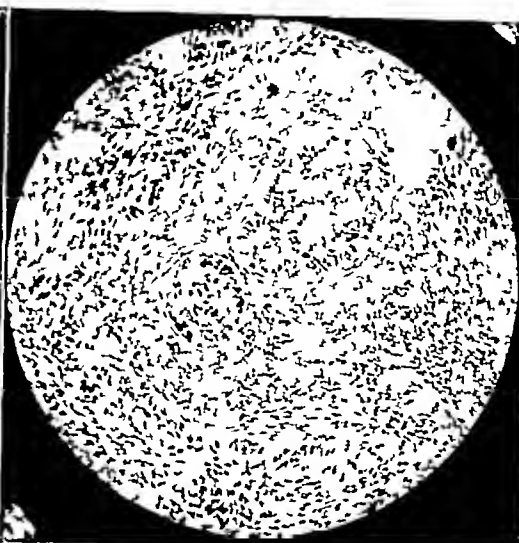


Fig 5

Fig 5 Photomicrograph  $\times 200$ , from same case

marking the site of the former neoplasm. Histologic examination of the wall of the esophagus in the region of the scar failed to reveal tumor cells.

High voltage x-rays administered through several portals, giving good palliative results in six cases, has recently been reported by Levitt.

The question as to the best plan of treatment in carcinoma of the esophagus cannot be answered in the light of present knowledge and experience. Whether surgery, x-rays, radium, or a combination of surgery and some form of radiation is to be the method of choice is a question to be determined in the future, as lasting clinical results accumulate.

It is in an endeavor to improve the outlook in cases of esophageal cancer that I thought it of value to report the following interesting case.

*Case Record*—Male, aged 53 years, when first seen in March, 1929, complained of difficulty in swallowing and substernal pain of about one year's duration. About a year previously, the patient had had a hemorrhage from his stomach, vomiting a large amount of blood. Thereafter, be-

cause he began to notice progressive difficulty in swallowing, particularly solid foods, he was on a fluid diet. The patient lost about ten pounds in the last three months, with considerable loss of strength. He had never been seriously ill before. There is no family history of cancer.

The physical examination showed evidence of loss of flesh and moderate pallor and weakness. He was able to walk about, but was weak and appeared to be chronically ill. The teeth were in very poor condition, showing pyorrhea and caries. The chest was barrel-shaped and hyperresonant. There were no palpable abdominal masses.

Roentgen examination of the gastrointestinal tract showed a marked dilatation of the lower end of the esophagus, and distal to this a tumor mass involving the esophagus and cardiac portion of the stomach. There were no pulmonary metastases.

Esophagoscopy under local anesthesia, using 10 per cent cocaine and adrenalin solution, showed spasticity of the upper portion of the esophagus, which yielded only after prolonged pressure. The mucous membrane was normal up to the junction

## A CASE OF BILATERAL OSTEOCHONDRITIS DEFORMANS JUVENILIS COXAE

(LEGG-CALVÉ-PERTHES DISEASE)

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WHILE oftenest associated with Perthes' name, this rare affection of the hip joint was originally reported by Legg (1) in America in June, 1909, although his first published contribution to the subject did not appear until February of the following year. In July, 1910, Calvé (2), in France, evidently unaware of the work of Legg, described under the title of pseudo-coxalgia a series of cases almost identical with those reported by the latter. Finally, in October, 1910, Perthes (3) published in Germany still another series of cases, apparently identical also with those adduced by Legg and Calvé earlier in the same year. Perthes entitled the disease described by him *arthritis deformans juvenilis*. However, he was subsequently obliged to alter the title, because of his inability to discover any evidence of inflammation of a portion of synovial membrane and head of the femur removed by him, rechristening the disease, in 1913, *osteocondritis deformans juvenilis* (4), the principal changes having later been found by him in the subchondrial bone in the head of the femur. In 1916, Legg (5) entitled the disease first described by him *osteocondral trophopathy of the hip joint*. Calvé (6) in his turn proposed in 1921 the substitution of the designation *coxa plana* for the less accurate title ultimately suggested by Perthes, believing it briefer and more truly descriptive of the character of the malady. From the foregoing history it is clear that to Legg belongs the credit for the discovery of the disease, and his name, therefore, most appropriately appears first in the eponymic triad in the subtitle of our article.

The affection under consideration may be defined as an acquired articular malformation characterized by flattening of the superior femoral epiphyses and regeneration of the epiphyseal osseous nucleus, the

articular contacts occurring in a defective manner and occasioning, under the influence of fatigue or suddenly accelerated growth, the development of painful symptoms similar to those experienced in all articular malformations.

The consensus of opinion is that the usual age of onset lies between three and twelve years, although the disease is occasionally encountered in adults. It occurs on an average of from two to four times more frequently in males than in females. While both hips are apparently equally liable, the unilateral is by far more common than the bilateral type. Thus, among 38 cases collected from the literature by Perthes (3) in 1910, there were 12 cases of bilateral affection in five males and seven females, ranging in age from seven to 30 years. Of 55 cases observed personally by Legg (5), seven were of the bilateral type. In 1919 Watkins (7) demonstrated a case of the latter form in a boy of five. Sundt (8), in 1920, reported his observations of seven cases of bilateral involvement (among a total of 75 cases studied by him), four of them in boys, the sex of the other three patients not being specified. In 1922, Platt (9) reported a series of 23 cases, twelve in males and eleven in females, two of them being bilateral, one in a boy of nine, the other in a girl of eight. Chruscz (10), in 1925, described a case of bilateral Perthes disease associated with clubfoot in a five-year-old girl. Wassink (11), in 1927, contributed a case of bilateral disease in a female patient of unstated age. In 1929, Kaiser (12) reported the occurrence of an apparently hereditary form of bilateral osteochondritis deformans coxae in several members of the same family. More recently, in 1931, Orth (13) described a case of bilateral Perthes disease, unsuspected and revealed by trauma, in a man 47 years of age. It is believed that no additional

fractioning of the dose and prolongation of  
the treatment

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absence of local tenderness, swelling, or muscular atrophy

Although it is extremely difficult in fre-

show irregular calcification, some parts revealing increased density, while others undergo rarefaction which continues until the



Fig 1 Case 1

quent instances to distinguish the condition clinically from epiphyseal coxa vara, tuberculosis, and other diseases, inasmuch as the radiographic appearances precede the clinical signs, the diagnosis can generally be made by roentgen rays. The radiographic changes peculiar to the disease consist briefly in the development of a distortion of the head of the femur, which apparently becomes flattened out, and in a broadening and stunting of the femoral neck. At first an increase in the density and a diminution in the size of the bony nucleus causes the head of the bone to appear flattened, the size of the epiphyses remaining unchanged, but the joint interval appearing larger, since less space is occupied by the bony shadow. The bony nucleus next begins to

bony nucleus appears fragmented (that is, broken up into areas wherein lime salts are considerably increased in amount, with intervals of diminished calcification between them). The cartilage, deprived of its bony support, and beginning to give way, loses its spherical shape and spreads out laterally. The deformed cartilaginous envelope surrounds the circumference of the acetabulum, and when the bony nucleus reforms, its shape is limited by the boundaries of its cartilaginous envelope. The fragments begin to coalesce, and the density of the entire epiphysis thereupon gradually diminishes until it becomes uniform and equal to that of the opposite side, eventually increasing in size until it practically fills its flattened, cartilaginous envelope.

eases of the bilateral type have since been recorded in the literature

The etiology of the affection has been continually in dispute. Various and sundry theories have been formulated and advanced in an endeavor to account for its origin. Chief among the more tenable of these are

(1) The *traumatic theory*, propounded by Legg (1), according to which the disease is the result of vascular imbalance between the head and the neck of the femur, in consequence of slight trauma to the part, a hypothesis supported by the history of trauma in the majority of cases

(2) The *developmental theory*, adduced by Calot (14), who believes that there is involved a condition of arrested development of the hip joint, marked by an imperfectly formed and shallow acetabulum and a small, malformed head, with a tendency to congenital dislocation of the hip, the result being that the head fits imperfectly into the acetabulum, with consequent osteochondritis from the mechanical disability. In this connection, Jansen (15) proposed a theory to the effect that, in subjects who develop pseudo-coxalgia, the curve of the acetabulum is flatter than the curve of the femoral head, this being caused either by excessive thickness of the bony floor of the acetabulum, or by inward deflection of the ischium in the direction of the mid-line (*ischium varum*). He asserts that these abnormalities are produced by a small amniontic sac, which either tends to flex and adduct the hip joint and lever the head out of the acetabulum, thus lessening the normal pressure of the head against the acetabulum, or by being drawn tightly over the buttock, bends the ischium inwards

(3) The *infective theory*, whose numerous supporters (among them Platt (9), its ablest advocate) declare that the condition is frequently associated with pyrexia, enlarged tonsils, or chronic ear disease, the defenders of the theory holding the view that the disease is hematogenous in origin like osteomyelitis, and pointing out the clinical resemblance of pseudo-coxalgia in its active stage to infective arthritis

Theories of congenital abnormalities of ossification, rickets, syphilis, and variations in activity of endocrine glands have been advanced in turn by their respective proponents and rejected because they were found to be based upon unsound evidence

In many instances the clinical symptoms and signs of the disease are so indefinite that it is unrecognizable in its early stages. The most common symptom during onset is a limp, which is painless and frequently intermittent, or a tendency to drag the affected limb, with, usually, a slight degree of muscle-spasm, the possible amount of movement in the joint depending largely on the extent of the latter. There may be slight or well marked muscular atrophy. Pyrexia is sometimes noted. During the active stage, which varies in length from about six to eighteen months, there are gradual disappearance of the limp (the latter, however, at times recurring sporadically for brief periods and occasionally continuing indefinitely), spontaneous disappearance of spasm, and, invariably, limitation of range of abduction and internal rotation and, less commonly, of flexion, this physical sign being often conspicuous. The restriction depends upon a combination of factors, namely, localized spasm of the adductor group of muscles, true shortening of adductors, and, in the later stages, the actual mechanical changes in the joint resulting from the deformation of the head of the femur. Prominence of the trochanter on the affected side is a cardinal sign. Shortening of the limb is rare, but, if present, is barely appreciable. The third stage of apparent recovery, with preservation of function in the hip joint, is characterized by the persistence throughout life of trochanteric thickening and a limitation of the range of abduction. Accordingly, while recognition of the affection is mainly dependent on radiography, a tentative clinical diagnosis is warranted in presence of the typical picture of symptoms of recent origin usually referred to one hip, *i e.*, a hip joint completely fixed by spasm in the position of adduction, undue prominence and palpable thickening of the trochanter, and complete

ture was good, but the patient limped on the left leg when walking. Thoracic and abdominal organs were normal. Genitalia were normal. Knee reflexes were present and equal. There was no limitation of motion or pain on manipulation of the lower extremities, particularly the left. There was no shortening. The ears were negative. The nose contained a slight amount of discharge, particularly on the left side. The teeth were small and well formed. Buccal mucosa was normal in color. The throat revealed evidence of a previous tonsillectomy, but there was a tiny tab of tonsillar tissue in the right tonsillar fossa.

Tentative diagnoses of tuberculosis of the hip joint, tuberculosis of the spine, and subacute epiphysitis were considered in turn. A tuberculin test was made (right forearm) and an x-ray examination of spine and hips was ordered. After 24 hours the site of the tuberculin test was inflamed, indurated, and elevated, the area measuring 2.5 by 3 centimeters.

Radiographic examination of the lumbar spine, pelvis, and hip joints showed the lumbar spine and pelvis within normal limits. The hip joints exhibited some slight irregularity of the articulating surface of the acetabulum, with fragmentation of the epiphyses of the heads of both femurs. There were small areas of destruction and proliferation of bone on the diaphyseal side of both epiphyses, with slight broad-

ening of the neck of each femur, especially the right.

Accordingly, a roentgen-ray diagnosis of bilateral osteochondritis deformans juvenilis coxae (Perthes disease of both hip joints) was established.

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The reformed femoral head undergoes molding which persists throughout life, resulting in one of two types of head, namely, globular-round or oval

The contour of the neck of the femur alters, its upper part becoming broader and its upper angle rounding off, until subsequently there is a shortening of the entire neck, producing an apparent *coxa vara*. In the beginning of this stage, an ill-defined zone of change in calcification produces a sponge-like area in the upper part of the neck, this metaphyseal change being early and constant. Later on, a regular pattern-like appearance is occasionally remarked, with zones of increased calcification arranged as pockets opening toward the epiphyseal line, each enclosing a corresponding area of rarefaction. This phenomenon is associated with fragmentation and disappears during healing.

There is some question as to changes in the acetabulum, certain authors being inclined to regard these as relatively unimportant, even if actually existent. Thus, Perthes (3) asserts that the acetabulum shows changes only in advanced stages, while Sundt (8) considers that the acetabulum is normal in the late stages of the disease. Platt (9), on the other hand, believes that changes visible at every stage should be regarded in part as the adaptation of the cavity to the altered lines of pressure through the deformed head, and partly as of the same nature as the transformation which the epiphyseal nucleus undergoes, and hence truly specific.

While spontaneous recovery without complete disability is the rule, there is considerable difference in the final results, particularly as regards function of the limb and comfort of the patient. Legg agrees with a number of other observers in the opinion that treatment has no effect upon the condition. However, it is generally believed that if treatment be instituted before the cartilaginous envelope of the epiphysis has become deformed, the subsequent malformation will be much less marked, although fragmentation and cyclical osseous changes will not be entirely

obviated thereby. The treatment most widely prescribed consists of fixation in an abducted position, the required duration of fixation being carefully controlled by repeated roentgen-ray examinations to determine the degree of recalcification attained by the head of the bone. In acute cases with a considerable degree of spasm and pain, fixation is sometimes insufficient for relief of the latter, and some form of extension apparatus may be required to overcome muscular spasm. Operative intervention is regarded as unwarranted by the majority of surgeons. However, in cases which subsequently exhibit roentgen-ray evidence of osteo-arthritis, operation for the purpose of remodeling the head of the femur may be advisable.

In view of the comparative rarity of the bilateral form of the affection, it is felt that the following history of a case from our own practice will not be devoid of interest.

A white, female child five years of age, when first seen on Aug. 30, 1932, complained of pain in her left leg. The patient was a first baby, delivered by instruments, her weight at birth having been eight pounds four ounces. Her father and mother had always enjoyed excellent health. The child was never breast-fed, but was put on a modified cows' milk formula. She had suffered from no contagious diseases save an attack suggestive of diphtheria in April, 1932.

Five months prior to consultation with us, the patient began to complain of stiffness in the left limb on arising, and, except in the morning, limped without pain during the day. When her attention was called to her limp, she would stop it. She was taken to a physician, who ordered more rest. Following this advice, the child was kept quiet for two weeks, during which time the limp disappeared, but recurred six weeks later, whereupon the patient was referred to us.

Physical examination revealed a fairly well developed, well nourished female child, with clear, tanned skin, and hair normal in amount and of good texture. There was no undue glandular enlargement. Pos-

x-ray treatment, the thickening of layers of connective tissue in the gland and the infiltration of these layers with lymphocytes without apparent change in the epithelium

Reports of observations of Walters, Anson, and Ivy, who treated the thyroid glands of dogs, showed hyperplasia. They also noticed considerable radioresistance on the part of normal thyroid glands of dogs.

The foregoing shows that the experimental literature gives no exact data of the effect of x-rays upon the thyroid, and that the work of the investigators is contradictory in its conclusions. Some of them (Krause, Ziegler, Pfeiffer, Rave, Fiorentini and Louraschi) maintain that x-rays produce almost no effect upon the parenchyma of the thyroid. As we have mentioned above, the others (Zimmern, Battez, Redaelli, Coulaud) point out the somewhat destructive effect, and some authors (Walters, Anson, Ivy) even speak of the irritative action of radiation upon the cells of the thyroid which results in their hypertrophy and hyperplasia.

The question of which we are treating is of enormous practical importance and, therefore, is worthy of the most careful attention. On this basis we made a series of experiments on the thyroids of rabbits, of which the following is the record of our histological examination.

#### EXPERIMENTS AND METHODS

For the experiment we took 20 male rabbits, aged from six to eight months. Fifteen were treated with x-rays, five being used as controls. The usual rules for x-ray treatment were followed. The equipment used was Koch and Sterzel's apparatus and the Coolidge tube. The distance, 24 cm, filter, 3 mm Al, voltage, 140 kv, 3 ma, dose, 550 r. (The dose was measured with Wolf's iontoquantimeter as well as by the calorimetric method with tablets using the Holzkecht scale.)

The first lot of rabbits were radiated three times, the second lot five times, and

the third lot, 10 times, the dose—550 r—was given once per day.

In order to study how time affected the development of the morphologic processes, rabbits were killed at 24 hours, six days, 12 days, 20 days, or 40 days after the treatment. For comparison, a control rabbit also was killed. The specimens of thyroid of both the treated and control animals were fixed with a Zenker formal with the addition of acetic acid (Miloslavsky's method) and then were passed through a series of alcohol baths of which the strength of the alcohol was in an increasing ratio. They were then embedded in paraffin in the usual way. Sections of from five to six microns in thickness were stained with hematoxilin-eosine.

The preparations made by this method served for general survey of the gland conditions, but for fine cytologic examination the specimens were prepared by the Shampy method with a subsequent chromicizing, the paraffin sections being from two to three microns in thickness. After removing the paraffin by treating the sections with  $H_2O_2$ , we stained them for chondroma, using Kull's method.

#### OUR INVESTIGATIONS

We are presenting the description of the thyroid gland of the control rabbit before giving the histologic findings procured by the examination of the thyroids of the treated rabbits.

Even with little magnification, when making preparation (Zenker—formal) fixation with the addition of acetic acid (Miloslavsky's method, and hematoxilin-eosine staining of a section) one may see that the organ is composed of follicles of varying size. The diameter of glandular vesicles varies considerably, but their main mass is composed of medium- and small-sized follicles. Large-sized follicles are comparatively few. The epithelium of the follicles is of a cuboidal or of a low columnar shape, nuclei in its cells are sappy, light-colored, and round, with a chromatic net lying rather loosely. Lum-



# THE EFFECT OF THE X-RAY UPON THE FINE STRUCTURE OF THE PARENCHYMA OF THE THYROID GLAND

(FIRST ARTICLE)

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## INTRODUCTION

SINCE the investigations of Williams (1901), who first introduced the x-ray as an important therapeutic factor in the treatment of thyroid gland diseases, this method has taken a definite place among all the other methods of treatment of Basedow's disease

We have a large number of clinical articles which mention the beneficial effect of the x-ray for the treatment of the mentioned ailment, though some of their authors point out the possibility of an increase of thyrotoxicosis (Gilmer, Kienboek) during the period of radiation and directly thereafter, as well as the possibility of the subsequent development of a myxedema (Cordua). Surgeons also stress the increased difficulty of future surgical interference because of the thickening of the thyroid capsula and adhesions with surrounding tissue after the use of roentgen therapy. We shall not discuss here the merits or faults of x-ray treatment for hyperthyroidism, but we do wish to point out that the foreign literature particularly, while based upon much clinical data, and while crediting x-ray therapy with much success in treatment of basedowism, is still lacking in exact experimental information upon that question and the experimental data we possess are insufficient.

Most investigators treat the question of decreased gland secretion in a purely theoretical way. Beck speaks of endarteritis obliterans which might be followed by atrophy of the parenchyma, but Professor Nemenow tells of a neutralization of poisonous substances. What do we find in the meager experimental morphological literature which we have on the action of the x-rays upon the thyroid

gland? We should say that the results of the investigations, as given by the authors, are very contradictory. Krause, Ziegler, Pfeiffer, Rave, Fiorentini and Louraschi found no changes in the radiated glands of animals. Coulaud's data showed that the normal thyroid glands of rabbits are extremely resistant to the x-ray, and that very strong doses—from 50 to 100 H E D—are required in order to produce a very insignificant decrease of secretion of the organ. But Zimmern and Battez, by radiating the region of the thyroid gland of rabbits, produced a cachexia resulting in the death of the subjects. The histologic investigation of the radiated organ showed its complete atrophy, together with the atrophy of parathyroid glands. This destructive action of x-rays upon thyroid glands is set forth in the investigations of Redaelli and Coulaud. Redaelli showed that the thyroid glands of rats which had been submitted to x-ray action at first show hyperemia of the organ and fading of the color of nuclei in the epithelium, then hydropic degeneration of cells and finally necrosis, accompanied by considerable inflammation in the gland and a fibrinous exudation and the emigration of leukocytes. The colloid became diluted and greatly vacuolated. Coulaud states that strong radiation provokes the degeneration of epithelium, and the nuclei in the cells of the organ change in size, are badly stained, and finally disintegrate.

Examination of human thyroid glands treated by x-rays seemingly shows that x-rays are greatly destructive. Murray observed the diffuse growth of the intra-alveolar connective tissue which could be a result of the atrophy of the parenchyma. Brehm found a sclerosed inflammation of the organ. Wagelin in one case of *struma diffusa et nodosa colloides*, observed after

*Experiment No 2*—A male rabbit, weighing 2,630 grams, was given one dose each day for five days. It was killed

with a great vacuolization of their protoplasm. The lumina of most follicles are filled with a loose, soft, granular, col-



Fig 1 Photomicrograph of chondroma of a normal thyroid gland



Fig 2 Photomicrograph of tissue from the thyroid gland experiment No 1 staining for chondroma (The same magnification as Figure 1)

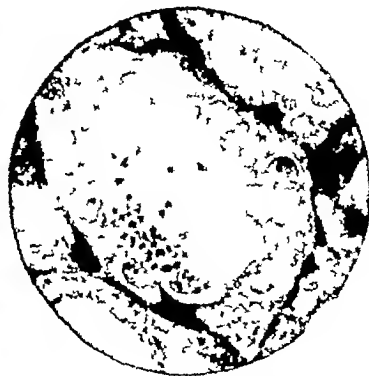


Fig 3 Photomicrograph of the same thyroid gland as shown in Figure 1 under stronger magnification

seven days after the last radiation. The preparation made by the usual simple method shows that the organ contains small and medium sized follicles. Large follicles were found more rarely in this than in the control rabbit gland. The cells of the epithelium of the follicles are of cuboidal shape and among the cells having the usual light colored, vesicle-shaped nuclei there are already very numerous cells with dark nuclei which seem sometimes to be larger than the neighboring light colored, unchanged nuclei, sometimes finer, sometimes having irregular polyhedral shape. We want to stress that it is impossible to find out with the preparation a law governing the distribution of cells with pycnotic nuclei. Sometimes they gather in a group of cells, sometimes they lie at the periphery of the gland, sometimes in the center separately among the cells which have kept their normal nuclear structure. The Kull method of staining shows us that chondrioma loses its regular distribution in cells of the epithelium. Large chondriomas with coarse appearance are disseminated over a cell and are not more thickly gathered at its apical pole. In numerous cells we observe nuclei stained darker and

loldal mass and in a portion of the glandular vesicles this loose mass fills only a part of the follicles or is disposed in the form of a very fine net. The vessels of the organ are dilated and filled with blood.

*Experiment No 3*—A male rabbit weighing 2,600 grams was treated with one dose per day for five days. It was killed 14 days after the last radiation. On the preparation we see that the follicles of the gland are medium- and small-sized, that the epithelium of most of the glandular vesicles is of the low columnar shape, and that there is a comparatively small number of cells with pycnotic nuclei.

When using the Kull method for preparing sections it is obvious that, though in some glandular vesicles chondrioma still keeps its coarse appearance and the protoplasm of cells with pycnotic nuclei is penetrated with vacuoles, yet in a series of follicles chondrioma becomes normal and has its regular place in the cell at the apex, where it is collected in the form of a small belt along the border of a follicle.

The colloid which fills the lumina of the follicles is fine, granular, and is rather often penetrated with large vacuoles. Vessels show no particular changes.

*Experiment No 8*—A male rabbit weigh-

ina of the glandular vesicles are evenly filled with homogeneous colloid. Among such follicles, though rather rarely, we found vesicles very much dilated by colloid. The epithelium of these follicles looks as though it had been flattened and the nuclei in the cells of this epithelium are flattened. In consequence of the chromatin being very compact in the nuclei they are deeply stained with hematoxylin. The cuboidal epithelium of the main mass of follicles has sometimes, though extremely rarely, the typical cells with darker stained nuclei.

We see that the large round nuclei, which are light bluish in color when the sections have been stained by Kull's method (fixation by Champy), usually are disposed at the basal pole of the cells in their middle third. Chondrioma is represented by the finest little sticks which are sometimes gathered in a chain-like arrangement (mitochondria). Usually chondrioma is more or less disseminated around the nucleus in the protoplasm of a cell, but as a rule it is gathered at the apical pole of a cell turned inside to the lumen of a follicle. Here the chondrioma is placed so thickly that microscopically this pole of a cell looks as though it were thickly dotted.

In general, one may say that the chondrioma of a rabbit's normal thyroid gland appears as an elegant piece of openwork. Colloid in the glandular vesicles represents a homogeneous rosy-stained mass, filling evenly the lumina of the follicles. Sometimes individual vacuoles of varying sizes are met along the border of the epithelium. In the individual cell elements, which normally are extremely rare, nuclei are darker. (They take the staining substance more intensively.) In such cells the protoplasm is penetrated with vacuoles and the chondrioma grains, which are larger and rougher than the normal cell grains, lie among vacuoles in loops of a protoplasmic net.

*Experiment No. 1*—A male rabbit weighing 2,560 grams was treated five days and received a 550 r dose each day. It was killed 24 hours after the last radiation.

The preparations, when the usual staining method is used, show no difference between the size of the granular follicles in the experimental and the control rabbits. The walls of the follicles present the cuboidal—or low columnar—shaped epithelium, as in the control rabbit, but a closer examination shows that in a number of cells the nuclei are stained considerably darker because of the more compact disposition of chromatin. In the individual follicles we notice that the colloid is vacuolizing at places where it touches the walls of the glandular vesicle. On the preparations made by Kull's method we see that the chondrioma of most of the cells of the epithelium is dainty and more or less evenly distributed in the cell protoplasm. The protoplasm of the cells (darker because their nuclei take the stain better) is penetrated with various sized vacuoles, and chondrioma in the shape of large coarse grains is disposed among vacuoles in the loops of a protoplasmic net. Sometimes the protoplasm in such cells with pycnotic nuclei seems to be separated from them and the nuclei look as though surrounded by light, transparent crowns. Often such cells with dark nuclei and with the vacuolized protoplasm are larger in comparison than the surrounding normal cells. Vacuolized cells are met much more often in the treated than in the control glands.

The homogeneous colloid in a number of glandular vesicles contains various sized vacuoles, but sometimes we find separate small clots, or occasionally a gathering of these clots which, because of the staining, have taken on a bright red color, though the colloid itself has taken a bluish-rosy color. We wish to stress the fact that by the usual technique of making the preparations, we cannot discover these small clots.

It is necessary to mention that in the gland of the treated rabbit the vessels lying in the interstitial connective tissue between the follicles are thickly filled with erythrocytes. No other changes were found by comparison with the control organ.

observed in the colloid may be explained as a change in its dispersivity under the influence of the x-ray

The degeneration of the cells of the thyroid as well as of its colloid depends upon the amount of radiation. The stronger the dose, the greater the number of affected cells. Here it is necessary to stress the fact that the degeneration of the number of cells was less in the animals which were given the same dosage, but which were killed in the early days after the radiation, than in the animals which were killed five or ten days after the last radiation. This confirms the opinion that x-rays affect a series of cell elements but that the process of degeneration is not simultaneously developed in them. Possibly the reason for this is that some cell elements take the direct action of x-rays, while the other cells get the rays by reflection, or possibly this unequal effect of x-rays is explained by the various functional conditions of the cells in the organ.

The disappearance of colloid in follicles, or the decrease of the colloid, may probably be explained by the fact that the action of x-rays stops for a time the production of colloid, whereas the destroyed colloid is probably quickly eliminated from the organ.

The connective tissue and vessels of the organ treated by x-rays show the thickening of the vascular wall and some proliferation of connective tissue around the large vessels. When much time has elapsed after the radiation we observe the thickening of the partition between the glandular vesicles. Depending upon the dosage, the above-mentioned process in the cells and colloid stops and they return to their normal state in from 20 to 40 days after the radiation. We observe that the return to normal consists of a gradual decrease of the number of cells in the state of necrobiosis, the chondrioma in the cells again returns to its fine granular structure and takes its definite location in the cell bodies. That is, it prefers to gather at the apical poles of the cells. The lumina of the follicles again begin to fill up with

the homogeneous colloid. In some experiments in which strong doses of x-rays were given, after the lapse of considerable time and the return of the organ to its normal structure we sometimes observed follicles with more highly and strongly developed epithelium than in the controls—the same findings as those of Walters, Anson, and Ivy. But we do not quite agree with the explanation of these investigators. Their opinion is that the action of x-rays provokes the hypertrophy and hyperplasia of cells in the thyroid. We consider that the x-rays provoke the destruction of a number of cell elements in the organ and that the hypertrophy of the remaining cells is the result of the greater activity that is forced upon them. Thus, the action of x-rays, when a large dose is given, finally produces an effect somewhat similar to thyroidectomy when the phenomena of compensatory hypertrophy are developing in the remainders of the organ (Zimnitsky, Zatvornitskaya, Lozovsky).

On the basis of the present data we came to the following conclusions:

- 1 The parenchyma of the thyroid is sufficiently resistant to the action of x-rays

- 2 The fine cytologic preparation of a thyroid reveals the processes that take place in the cells more fully and more quickly than the usual morbid-anatomic methods and permits the observation of the initial steps of the changes taking place in the cells under the action of x-rays

- 3 Changes in the cells of a thyroid under x-rays deal with the protoplasm as well as with the nucleus and chondrioma. In the cell protoplasm there appear vacuoles of various sizes, chondrioma becomes coarse and granular and loses its regular distribution in the cell body, the nucleus of such a cell undergoes pycnosis, and some of the affected cells finally disintegrate

- 4 The action of x-rays upon the organ follows the so-called "island principle"

- 5 In addition to the foregoing changes taking place in the individual cells of the thyroid (the number of these cells de-

ing 2,480 grams was given three doses at one session and killed five days later. The histologic appearance was the same as that observed in Experiment No. 3.

*Experiment No. 12*—A male rabbit weighing 2,530 grams was given three doses at one session and killed 40 days after radiation. Preparations made for a general survey by the usual method show almost no difference of the construction of the gland in comparison with a normal gland, except that here and there we see some individual pycnotic nuclei. Preparations made by the Kull method show cells with chondrioma of a soft, fine appearance and follicles filled with a homogeneous colloidal mass. Vacuolization of the protoplasm is observed only in a few cells with pycnotic nuclei. In general we must say that the structure of the gland is nearly normal with the exception of the size of the vessels, the walls of which are thickened, the endothelium proliferated, and the lumen sometimes reduced. In consequence of all these changes we find a thickening of the interfollicular partitions.

In conclusion, we must mention that in several experiments in which the animals were treated with large doses of x-rays (up to 10 H.E.D.), and in those cases in which considerable time elapsed between the last treatment and the killing of the animal, the structure of the thyroid when observed microscopically was nearly normal and it is possible that the only thing of importance was a somewhat higher epithelium in the follicles than in the normal gland.

#### DISCUSSION OF FOREGOING OBSERVATIONS

Interpreting the foregoing data we see that the technique of the morphologic examination of the organ is a very important factor for revealing the effect of x-ray action upon the thyroid. In our experiments in which the animal was given from three to five H.E.D. and killed 24 hours after the last radiation, the sections prepared by the usual method (Zenker—formal fixation, hematoxylin-eosine stain-

ing) showed nothing but pycnosis in some nuclei.

By using the finer cytologic method for making the preparations we obtained quite a different picture. We see here not only the pycnosis in the nuclei, but many structural changes in the cell as well as in the colloid filling the follicles. The cell protoplasm is penetrated by a great number of vacuoles and the chondrioma of the cells under the influence of x-rays is roughened, unevenly distributed in the cell body, and shows the evidence of degeneration. Colloid filling the follicles undergoes a peculiar process of disintegration. First, small, individual, more compact and darkly stained clots appear, second, vacuoles of various shapes and sizes may be seen, third, the homogeneous colloid becomes granular and finally it nearly disappears in many of the follicles. Here it will be interesting to call attention to the manner in which the x-ray acts destructively, according to what we call the "island principle", that is, the destruction of isolated cells or groups of cells with an accompanying lack of demolition of the parenchyma as a whole.

Bordier presumes that the x-ray changes the colloids of high dispersivity into colloids of a lower dispersivity. The observations of the Academicians Nadson and Rokhlina prove that the homogeneous plasma becomes somewhat foggy one hour after radiation. This change indicates a lowering of its dispersivity. With these apparent changes of the protoplasm, the nucleus itself at first does not show any changes, but soon it also becomes foggy, its fine granular structure becomes coarser, and the contour of its nucleus becomes more distinct. Our observations show that under the x-ray action, first chondrioma suffers degeneration, then the cell protoplasm degenerates, and then comes the pycnosis of the nuclei.

Thus our finding concerning the effect of x-rays upon the cell and its organoids coincide with the observations of Academicians Nadson, Rokhlina, Vail, Frenkel, and Jasvoin. The destruction which is

# CALCIFICATION OF THE BRAIN CORTEX ASSOCIATED WITH HEMANGIOMA OF THE FACE AND MENINGES

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A NUMBER of cases have been described recently in which a hemangiomaticus nevus of the face is associated with a calcified intracranial hemangioma. The following two cases are further examples of this affection

## CASE REPORT<sup>1</sup>

**Case 1 History**—F D, a boy, aged 8 years, who gave no history of familial disposition. One younger sister is normal. Shortly after birth the parents noted a port-wine nevus on the left half of his face. The mother states that at the age of four months the patient had an attack of high fever with fits, and after that "paralysis of the right side." Since then, he has had several fits daily which last one or two minutes. The child is very active during the day and very restless at night. He does not go to school.

**Examination**—The patient is normal in size and development. He weighs 22.3 kg, length is 121 centimeters. The left side of the face is the seat of a large angioma of the "port wine-stain" type, which extends from the nose over the left side of the forehead, otherwise his skin is normal. His skeleton and internal organs do not show anything abnormal.

**Neurologic Examination**—The patient's left pupil is larger than the right, and his right pupil reacts less to light than his left. His right eye is in position of abduction which is maximally increased on convergence. His vision as far as can be tested is R, 5/50, L, 5/15. Eye fundus nothing abnormal. The patient has facial paralysis on the right side, the other cranial nerves are normal. His right arm shows spastic pare-



Fig 1 Lateral view of the skull in Case 1. Films show sinuous shadows in the region anterior to the coronal suture but more pronounced in the region of the parietal bone and occiput on the left side, which seem to imitate the gyriform appearance of the brain cortex. There are no shadows in the area of the cerebellum. The opacities are strictly localized on one side, showing a very sharp and straight medial border a little to the left of the middle line.

sis with increased reflexes. The right arm is 3 cm shorter than the left. There is no marked atrophy. There is slight motor weakness of the right leg as compared with the left. Knee and ankle jerks are equal on both sides. Sensation is normal, with no ataxia. Speech and intelligence are normal. The child writes his name with his left hand, and is able to count.

**Description of Fits**—At the onset the child yells, falls to the ground, becomes rigid, his face pales, and he is incontinent. The fit lasts for about one minute.

**Radiogram**—The skull films (Figs 1 and 2) show, in the region anterior to the coronal suture but more pronounced in the region of the parietal bone and occiput on the left side, sinuous shadows which seem to imitate the gyriform appearance of the brain cortex. In extent they correspond to convolutions of the frontal, parietal, temporal, and occipital lobes of the cerebrum.

<sup>1</sup> The cases were observed in the x ray department of the Rudolf Virchow Hospital, Berlin. The first case was sent to the hospital by Dr B Bendix to whom I am indebted for the clinical history.

pending upon the strength of the radiation of the organ), chondroma under the action of x-rays in all the cells of the gland undergoes degenerative changes, that is, becomes coarse and granular and loses its regular disposition in the cell body, while the nucleus and the protoplasm of the cell keep their morphologically normal structure

6 Colloid in the follicles of the irradiated thyroid becomes granular, undergoes vacuolization, and decreases in quantity in the organ

7 The structure of the thyroid regenerates when a lapse of time is permitted after radiation (The period of time is in direct proportion to the strength of the radiation) In the experiments in which we used large doses of x-rays and permitted a period of time to elapse, we sometimes noticed the reconstruction of its normal structure, higher epithelium in follicles, and increase of colloid in the organ These observations may be explained by the compensatory hypertrophy which develops in the cells of the gland in consequence of the disintegration of a number of cells affected by x-rays

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anything abnormal    Skeleton and internal organs, no pathology

*Radiologic Examination*—There is enlargement of the left orbit (Figs 3 and 4) There is a slight deviation of the septum nasi to the right The left petrous bone seems to be larger than the right, especially on the films in the Stenvers position, but also on comparison in the postero-anterior view The arcuate eminence stands out more distinct on the left side than on the right Postero-anterior and lateral views show small irregular opacities disseminated over the area of the left frontal, parietal, and occipital bones Superimposed over the posterior border of the helix are sinuous double contoured lines (as seen in the previous case) All parts of the left hemisphere seem to be involved, although in different degrees

*X-ray Diagnosis*—Multiple intracranial calcification, probably due to calcified intracranial hemangioma

#### DISCUSSION

In discussing the two cases attention may be directed to a recent paper by Knud H Krabbe, who has compiled the literature on this subject and has himself observed five cases, one of which he was able to study histologically

Probably the first one to describe a case of nevus vasculosus combined with hemangioma of the leptomeninges and hemiplegia was S Kalscher, in 1897 and 1901 The first x-ray films of the same affection were published by Parkes Weber, in 1922 and 1928, and by Dimitri, in 1923 Reference may be made to the excellent monograph on angiomatous tumors of the face by Cushing and Bailey, who discuss the pathology and clinical picture of the disease The last named authors had never observed any case like the two described in this paper, but mention those described by Dimitri and Marque Beside the papers listed by Krabbe, Williams, in England, and Dyes, in Germany, have recently published cases which in the x-ray appearances are almost identical with those of Case 1 of this paper



Fig 4    Postero anterior view of the skull in Case 2 (See caption for Figure 3)

In their book, Cushing and Bailey point out how these vascular malformations may occur The association of congenital nevi of the skin with telangiectatic tumors of the meninges and brain can be explained only on an embryologic basis, since originally the circulations in the different layers of the cranium are all derived from the same source

The question we are most concerned with is What is the anatomic substrate for the described calcified shadows in the x-ray films?

From the symptoms in our first case we may consider the presence of a tumor involving the motor cortex, which, on the basis of our clinical and pathologic experience, we may diagnose as an hemangioma of the leptomeninges, the dilatation of the vessels presumably localizing in the veins of the pia (Cushing and Bailey) According to these authors no arterial angioma of the brain has been reported in association with a nevus vasculosus of the face Since we know that calcifications in hemangio-





Fig 2 Postero anterior view of the skull in Case 1 (See caption for Figure 1)



Fig 3 Lateral view of the skull in Case 2. Films show enlargement of the left orbit. The left petrous bone seems to be larger than the right. The arcuate eminence stands out more distinctly on the left side than on the right. Small irregular opacities are disseminated over the area of the left frontal parietal and occipital bone. Superimposed over the posterior border of the helix are sinuous double contoured lines.

There are no shadows in the area of the cerebellum. The opacities are strictly localized on one side. They show a very sharp and straight medial border a little to the left of the middle line. In cases in which the sinuous shadows correspond to the sulci of the brain, we usually find two lines running parallel for a distance of about one millimeter. But toward the periphery, where the lines seem to correspond to the surface of the gyri, they are single. Anteriorly, in front of the coronal suture, the described arrangement is not as distinct. The skull bones present a certain asymmetry, a small sella, and a non-pneumatized sphenoidal sinus, otherwise, they are normal. Stereoscopic examination does not give further information in regard to localization of the described opacities.

The diagnosis at which we arrived was calcified intracranial hemangioma.

**Case 2 History**—R. S., a boy, aged 7 years, who gave no history of familial disposition. At birth the mother noticed a

nevus occupying the whole left side of the face, as well as a marked enlargement of the left eyeball. Since the age of about six months the child has been unable to see anything with his left eye. Four days before admission to the hospital he had a hemorrhage in his left eye. Further, there is nothing abnormal in the history.

**Examination**—Seven-year-old boy of normal size and weight. There is slight hypertrophy of the left half of the chest and the upper extremity. The whole left side of the face is occupied by a nevus vasculosus, which extends over the cheek and forehead and is sharply limited against the middle line. There are small teleangiectatic spots on the right side of the face, and pronounced asymmetry of the whole face.

An examination of his eyes revealed the following: the right is normal, the left shows buphthalmus. There is a hematoma of the anterior chamber, which is filled completely with blood. Examination of the left fundus was not possible. Vision in his right eye is 5/25, and in his left *nil*. Intraocular tension is normal on both sides. Neurologic examination does not reveal

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mas are rather common either in the wall of vessels or as calcified thrombi within the lumen (Dunn, McCallum, Ruggles), we are inclined to think of the opacities in our cases as calcifications localized in the wall or lumen of the vessels. This probably explains the scattered irregular shadows as we find them in our second case.

The sinuous opacities, which are so outstanding in our first case and also visible on one plate in the second case, have been explained in the literature (Parkes Weber, Brushfield and Wyatt, Brinton) as diffuse calcified meningeal hemangiomas, the calcareous deposit localizing in the pia mater which closely follows the brain convolutions. Postmortem findings by Krabbe suggest another explanation. In his case, the x-ray picture of which is almost identical with ours, the pia mater did not contain any calcifications either in the connective tissue or in the vessels, although it was somewhat angiomatous. All the calcifications were localized in the brain cortex which appeared to be scattered with lime salt deposits of different sizes and shapes. The granules were situated for the most part in the superficial layers of the cortex and had no relation to the vessels. In the calcified areas the number of nerve cells was considerably reduced. Krabbe believes that the changes in the brain are not secondary to angiomas of the pia mater. The syndrome should be related to a more generalized malformation of the organism, originating in fetal life, which leads to angiomas of the face and pia as well as to aplasia, sclerosis, and calcification of part of the brain cortex. The x-ray films and postmortem findings in a similar case published by Brushfield and Wyatt, in 1928, though having escaped general attention, are of great interest in the light of the findings by Krabbe. In their case the cerebral cortex showed a general deficiency of neurones. Beside a nevroid condition of the meninges, there were scattered through the portion of the cortex underlying the angioma minute round bodies, varying in size and distinguishable from pigment granules by their refractile center. No real explana-

tion for these structures was advanced, the pathologist considered the possibility of protozoa being present. In view of the findings by Krabbe, we may be justified in assuming that the described structures were granules of limesalt scattered through the surface of the brain.

There are some points in the arrangement of the sinuous shadows which give support to the theory that calcium is not localized in the wall of vessels of the pia mater, but in the brain surface. With Dyes, we can assume that calcifications of the vessel walls would not be in a continuous, uninterrupted line as we see it in our case. The roentgenogram, especially at the periphery of the opacity, gives the impression that the whole area is impregnated with calcium.

Peculiar to all described cases is the preference of calcifications for the posterior parts of the cerebrum, although our first case shows some in the frontal area. The cerebellum seems always to be free of the affection.

Finally we may mention the frequent association of nevus vasculosus of the face with congenital hydrophthalmus, which we find also in our second case, either as an expression of general malformation or as a sign of local angiomatous affection of vessels of the eyeball.

#### SUMMARY

Two cases, presenting association of extensive nevus of the face with peculiar intracranial calcifications, are reported. The clinical symptoms of hemiplegia in one case suggest the presence of an intracranial hemangioma involving the motor cortex. In view of the micropathologic findings in a similar case, and of the arrangement of the sinuous shadows in the x-ray films, it is assumed that the calcifications are probably localized within the superficial layers of the brain cortex. The second case presents a congenital hydrophthalmus.

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physician who had qualified as a roentgenologist, protested against being examined and questioned on any other subject. Inadvertently, however, later during the course of the trial, he attempted to answer a question relative to certain surgical technic and was very properly prevented from so doing.

During the last forty or fifty years particularly, medical expert testimony has figured prominently in legal actions before courts. While at first this kind of testimony was received by the courts and juries with the respect and deference which honesty, learning, and intelligence deserve, in more recent times, particularly during the last fifteen or twenty years, numerous elements in the methods of procuring and introduction of medical expert testimony have tended to place it in a much lower plane than it formerly occupied in the esteem, confidence, and honored regard of the judiciary, the bar, the press, and the public. Probably the principal reasons for the apparent lowering of the esteem and credit in which expert medical testimony is held lie in the seeming and at times quite evident partisanship of some of the expert witnesses, the employment of physicians to give expert testimony whose qualifications in education, special training, and experience fail to properly fit them for such service, the frequent appearance in court of certain physicians who make a business of testifying and thereby become professional expert witnesses, and last, but by no means least, the impression—given out mostly by certain unscrupulous members of the legal profession—that expert witnesses can be secured who will testify to anything, one way or another, at so much per day.

All these elements acting conjointly and together, have had a tendency to very materially lower the credibility of the medical expert testimony from its once high pedestal, yet among the better class of attorneys, who are known to handle only cases which have genuine merit and who are careful to employ—or call—only

such expert witnesses as have a standing and reputation for probity above doubt or challenge, medical expert testimony still occupies a high rank, is listened to with respect, and is heeded when so introduced. Given such conditions, under usual circumstances this kind of testimony is considered as convincing and worthy of credence as honest, decent, and law-abiding citizens are accustomed to concede to their physicians.

Naturally, it is of utmost importance that those who render expert medical testimony should be actually well qualified so to do. Unfortunately, attorneys—who choose nearly all expert witnesses—are not always able, either from ignorance or other reasons, to secure those who are entirely competent. Often attorneys do not care to pay adequately for the time of those who are in every way competent, and shop around until they find some one who will be "just as good," who will appear for a cut rate. The saying that "everyone loves a bargain" applies here. Also, some mediocre men, who are tempted by the apparently lucrative fees to be earned as expert witnesses, are willing to shade their opinions and even allow their consciences to become elastic, in order to secure the employment and get the fee.

An example of this sort may be related from the experience of the writer in a *spinal injury case*.

In a suit tried before the Superior Court of Cook County, Illinois, in which an estimable young woman of high type had brought action against a railroad company for injuries resulting from an accident to her spine, the plaintiff had had roentgenographic examinations made by me, a few months before her injury, while searching for a suspected renal calculus. Films made of the same region after the accident disclosed definite and certain changes in the spine and the sacro-iliac region. A physician employed by the claim department of the defendant corporation admitted that there was unquestionably some injury shown in the films and informed me that he would recommend settlement of the claim.

# SOME LAWSUITS I HAVE MET AND SOME OF THE LESSONS TO BE LEARNED FROM THEM

(Ninth Installment)

By I S TROSTLER, M D , F A C R , F A C P , Chicago

## EXPERT TESTIMONY

SINCE the appearance of the first of this series of articles and experiences in September last, about thirty-five readers have written asking me to discuss the general subject of expert testimony. Therefore, while not strictly in line with the general trend of this series, it approaches so close—and, in fact, does include—some of the lawsuits I have met as well as the lessons to be learned therefrom, that I will try to epitomize the subject in this installment.

It may be interesting to many to know the *origin of expert medical testimony*.

Expert medical testimony originated about the middle of the fourteenth century in England, where, during a trial of a criminal case, the justices before whom the trial was being held were unable to determine to their satisfaction, and from inspection and their knowledge, whether or not a certain injury constituted mayhem. In order that they might have the benefit of an expert's opinions in evidence, they called surgeons from London, "*Ad informandum dominum regem et curiam*"<sup>1</sup>

This innovation proved to be so illuminating and cleared the problem so satisfactorily that the experiment was decided to be a pronounced success. Since that original use of expert medical testimony, surgeons, physicians, and more lately specialists in the various branches of medicine, have been called to assist the courts and juries to understand and comprehend medical and surgical technicalities, until at this time medical experts are called upon to give expert testimony more often than all other expert witnesses combined.

Expert testimony has been much dis-

cussed both in lay and medical publications, but is such a broad subject that there is always plenty to be said without repetition.

An extremely important matter centers around the limitations of the testimony permitted to be given by an expert witness. It must be evident that upon exactly how a medical expert witness qualifies or has been qualified, depends the scope of the expert testimony he may be expected or allowed to give.

Not infrequently—particularly in the smaller communities—physicians are qualified in general medicine or as all-round medical experts. Consequently, such excessively broad qualifications pave the way for almost any kind of questioning upon medical subjects. However, nearly every medical expert witness prefers to designate what he shall or shall not be qualified as expert on (and he is wholly within his rights in so doing). If the witness knows what is best for him he will insist upon being qualified on his specialty only, unless he desires to be qualified as a general practitioner.

Surgeons, pediatricians, radiologists or any other specialists may be qualified in their own special lines of practice and not be subjected to the embarrassment of questioning upon subjects with which they are not expertly familiar. Since it is well known that every conscientious physician is qualified to answer correctly only a comparatively few questions outside of his own specialty, such limitation of expert qualification carries with it distinct and definite advantages for the medical expert witness who desires to avoid questioning outside of his special expert knowledge.

In a rather celebrated Louisiana case<sup>2</sup> a

<sup>1</sup> Liber Assize (28 Edw III) 145 Pl 5

<sup>2</sup> State vs Scruggs 116 So R 206

cupied by a question propounded to Dr Hickey, to which the good Doctor's answer was, "Yes, the question is too indefinite to give an answer." Again, immediately following the foregoing in Dr Hickey's direct examination (on page 455), an hypothetical question consisting of 427 words was asked, which was answered in 17 words

Superficially, and without an intimate knowledge of the facts, it may appear that even amply qualified and sincerely honest expert witnesses disagree with each other and apparently flatly contradict each other's testimony. However, speaking from many years of observation from the outside and experience on the inside, I can say with every certainty of being correct, that such differences of opinion and contradictions are only apparent and not at all real. The explanation is very simple and easy of comprehension. It is simply that the seeming contradictions and diametrically opposite opinions among honest witnesses are based upon the manner of asking and the verbal construction of the hypothetical questions. The subject or subjects of the question are presented so differently by the astute word-twisting attorneys for the opposite sides of the suit, that it is usually absolutely impossible to answer them alike and for the answers to agree with each other. Attornies' forensics make more for disagreement of witnesses than do any other thing, and if these same medical expert witnesses were to meet in a consultation room or over a patient, *they would in all likelihood agree entirely and explicitly upon the identical propositions or problems upon which the smooth-tongued attorneys make them appear to disagree when on the witness stand in court*. I know this and have seen it in almost innumerable instances and have been slyly joked about it by friends in the legal profession. I once introduced such a lawyer, a really able trial lawyer, as "my friend, Mr B", who has probably succeeded in making more physicians lie than any man I knew." He came back at me, as soon as he had a chance, by saying that it was easy to make

Dr Trostler lie—all he need do was to ask him an hypothetical question

Of course, the attorneys for both sides of a suit use every possible means to bring out the testimony which, in their opinions, will influence the court and jury to decide in favor of their clients and against the other side of the case. Consequently, the statements and testimony of expert and other witnesses are often purposely misunderstood and distorted by the keen, word-twisting paraphrastic forensics. It is this distortion and word-twisting of the attorneys, causing the apparent (but seldom real) contradiction and disagreement, that has called down so much unfavorable criticism and comment upon medical expert testimony, and the tendency to discount its value in determining matters of critical and scientific importance.

As trials are nowadays conducted, it is almost impossible for expert witnesses on opposite sides of any lawsuit to agree. This is, as previously stated, because the witnesses for the two sides are not asked questions nor are they expected to give opinions upon the same assumptions. Attorneys for each side frame and formulate hypothetical questions which differ as night does from day, each omitting all that portion of the evidence or any items which will damage his side of the case, and including every iota of what may or might benefit his side. This is sometimes done to so extreme a degree that—in some instances within my experience—the opinions of the expert witness were rendered entirely worthless and were thrown out by the clear insight of the judge before whom the testimony was given.

The principal difference between ordinary testimony and expert testimony is that the former consists of the recital of facts and actual incidents connected with the cause under investigation, while the latter may be, and usually is, a recital of both facts and opinions by persons who have convinced the court that they have sufficient expert knowledge concerning the particular subject, trade, or profession or other technical matter to enable them to

The attorneys for the railroad company insisted upon going to trial with the suit. At the trial, the writer appeared as an expert witness, being called in that capacity by the plaintiff. The differences between the two sets of films made before and after the accident were explained, and then the expert witness was (surprisingly) excused without cross-examination. Two other physicians, neither of whom had any standing as roentgenologists, testified that the two sets of films showed identical and normal conditions.

At the request of two of the jurors, the writer was recalled to the witness stand and again asked to explain the differences between the condition found in the two sets of films. My testimony was entirely upon the interpretation of the films as I saw them and showed them to the jury. Evidently my testimony established the claims of the plaintiff, as the jury rendered a verdict for her and fixed the amount of her damages at \$11,000, which the railroad company immediately settled for \$9,000.

One of the physicians who had testified that the two sets of films showed identical and normal conditions came to me afterward and said that he had listened to what I had said when recalled to the witness stand, and shamefacedly admitted that if he had known there was so much difference, as explained by me, he would not have testified. He admitted that he had not seen the films before examining them while on the witness stand, and that he had not known who had or would interpret them.

This was just one of those instances in which a man was selling his testimony, irrespective of right or wrong, and it is related to illustrate one of the reasons why medical expert testimony is often regarded as unreliable.

When witnesses have been qualified satisfactorily to the court, so as to enable them to give expert testimony, they are generally subjected to direct questioning, as is the custom with ordinary witnesses. In addition to the direct questioning, or

what is known as direct examination, they are frequently asked what are known as hypothetical questions.

Hypothetical questions are generally based upon facts relative to the cause on trial which the expert witness has not personally observed. They are usually founded upon facts or evidence which have been introduced in the trial, and contain such portions of the evidence as the attorneys propounding the hypothetical questions desire either to prove or to disprove, and only that portion of the aforementioned evidence which will be helpful and of advantage to a given side of the situation. Consequently, a carefully outlined statement of the facts or evidence is stated to the expert witness and he is usually asked if he has an opinion regarding the same. Of course he has an opinion or he would not be there. He is then (usually) asked, What is that opinion?

Customarily the hypothetical question is so prepared that it may be answered by "yes" or "no," and the expert witness is expected to answer it in that manner. However, it is within the experience of all who have been on the witness stand as expert witnesses, that some hypothetical questions cannot be answered by a simple "yes" or "no." Generally this is due either to faulty questioning or to lack of exact knowledge of the technical subject which comprises the cogent reason for propounding the question. In such instances, the witness, if he knows his strength (in that he knows that he knows more about the subject than the questioning attorney can possibly know), will state that *the question cannot be answered "yes" or "no" without qualification*.

These hypothetical questions are sometimes extremely complicated and intricate in their ramifications, and extremely lengthy. I have sometimes answered such questions that required as long as thirty to forty minutes for the questioning attorney to read. In the second installment of this series, published in October, 1935, will be found a verbatim transcript of one of that type. On page 454, the entire page is oc-

Thus it will be readily seen from the very nature of this situation, relative to the admissibility of hearsay testimony and evidence, that it obviously becomes a matter almost entirely and exclusively under the control and discretion of the courts and lawyers and *not at all under the control and discretion of the witness on the stand*

Whether or not certain testimony becomes admissible or is to be rejected as inadmissible hearsay evidence, depends entirely upon the conditions and circumstances under which it is offered. What may be decided to be proper and acceptable in one case, may be rejected as improper in another. Considerable more of what is commonly considered to be hearsay testimony, such as the recital of symptoms, pain, dying declarations, records, etc., is often allowed in connection with medical opinions and medical expert testimony than in any other kind of testimony. However, while the narration or recounting of symptoms and patient's complaints may be admissible when given in the testimony of a physician, the same testimony is not admissible when it is given by other persons than physicians, and physicians are not permitted to testify as to opinions based thereon. This is the meaning of an Arizona Supreme Court decision.<sup>7</sup>

And, as is elsewhere stated, even expert witnesses may give expert testimony only concerning matters in which they have qualified as experts.<sup>2</sup>

Referring back to the lowered opinions of the judiciary, the bar, the press, and the public relative to expert testimony, an example of what was thought of this subject by a leading New York newspaper, nearly forty years ago, may be gleaned from the following editorial published in the *New York Journal* for Oct. 2, 1897:

"A Lesson in Expert Testimony"<sup>8</sup>—"Mr

<sup>7</sup> Security Benefit Assn vs Small 272 Pac R., 272

<sup>8</sup> I am indebted for the foregoing to Dr. Ramsay Spillman, of New York City, a radiologist who thinks much as I do relative to medico-legal matters. He found this while browsing through some old newspaper files in the Congressional Library in Washington. He

Anthony Comstock has encountered an unexpected obstacle in his crusade for the purification of all minds but his own. Having been informed that a certain Hebrew book was (*sic*) congenially filthy, he haled a dealer who sold it into court, and produced an expert interpreter who translated certain selected passages in a manner highly satisfactory and unfit for publication. Thereupon the defense produced another expert in Hebrew pornography, and this authority translated the suspicious paragraphs in a way that could not bring the blush of shame even to the sensitive cheek of Mr. Comstock. The court was at sea, and finally adjourned the case, to enable the parties to amass more contradictions from conflicting linguists, which each side promised to do.

"There must be judges in New York learned in the Hebrew tongue, and it would seem as if this controversy might have been brought before one of these for a judgment independent of the Comstock and anti-Comstock philologists. But the incident neatly illustrates the value of expert testimony, as our legal system has developed it. There is only one thing less to be depended upon in court than an expert, and that is another expert. The only way to attain any approximation to trustworthiness in this class of testimony is to have the experts employed by the public in the interests of justice, and not in the interests of either side. The specialists might have fewer jobs under that system, but they would command more respect."

#### FEES

The subject of medical expert testimony can scarcely be considered to have been discussed unless at least some mention has been made of expert witness fees.

Before taking this subject up at all, it should be stated in no uncertain terms

wrote me: "I thought, as I laboriously copied it in pencil on the back of an envelope (all I had with me to write upon), *this will be nuts for Trostler*."

When I have induced men of this type to think of me when they see something that will be 'nuts' for me, I feel as though I have done considerable toward making my colleagues and confrères law-conscious and that my efforts have been worth while.



reach reasonably correct and logical conclusions from facts recited, given, or placed before them. These conclusions are called "opinions," and, when logical and based upon either the testimony of ordinary witnesses or known facts connected with the cause under investigation or trial, constitute expert testimony.

But it must be understood and no mistake made in understanding, that no witness, either ordinary or expert, may reach illogical conclusions and state such as expert testimony.

In other words, common or factual testimony relates to impressions received by the five senses and is, therefore, objective, whereas, opinion or expert testimony consists mainly of the mental reactions and conclusions derived therefrom, as the result of previous sensory impressions based upon experience and knowledge, and is a subjective procedure.

As stated, expert witnesses are permitted in their testimony to give their opinions, because of their superior knowledge. They are qualified (or supposed to be qualified) to be able to formulate correct opinions about the facts involved, wherein ordinary persons are lacking in the special skill or knowledge of the subjects in question.

It is obvious to my readers that many scientific facts are entirely—or perhaps we better say more or less—meaningless to the average person and, as such scientific facts may, and frequently do, have great and important weight and value in the correctness or justice of certain acts, claims, or propositions, it is necessary and proper that such scientific facts be elucidated, explained, or demonstrated by those trained and educated to properly present them to the court, the judge, or the jury.

It has been aptly said "Expert testimony is admitted because the witnesses are supposed to have knowledge upon the subject of inquiry which jurors generally have not, and are therefore supposed to be more capable of drawing correct conclusions from facts and basing opinions upon them than jurors are generally presumed to be."<sup>3</sup>

"While it may be true, that an expert witness may give reasons for his opinion, he is not required to do so. The facts contained in the hypothetical question propounded to the witness are in themselves reasons for an answer," according to the Appellate Court in California, as expressed in its decision in *Thomason vs Hitchcock*, 46 P. R. (2nd), §32.

While expert witnesses are not generally or as a rule expected to testify as to facts, as is an ordinary witness, in a considerable number of leading cases the expert's testimony has been a combination of factual and expert knowledge. Thus, in a New Jersey case,<sup>4</sup> a medical expert witness was asked regarding the subjective symptoms which the patient (defendant) complained of, and witness was permitted to answer and then formulate his opinion as an expert relative to the patient's (defendant's) condition from these subjective symptoms. However, it must be remembered that information of that kind may be so used *only when such information is elicited for the purpose of treating the patient*.

When information is elicited for the purpose of leading the physician to form an opinion, regarding which he can testify for the patient as a witness only, such information is not admissible in evidence on behalf of the patient. This is incorporated in the decision in another New Jersey case.<sup>5</sup>

In still another New Jersey Supreme Court decision,<sup>6</sup> the Court said "While a witness who is not an expert may testify only to such exclamations and complaints as indicate present existing pain and suffering, a physician may testify to a statement or narrative given by his patient in relation to his condition, symptoms, sensations and feelings, both past and present, because in this way only can the bodily condition of the patient be ascertained."

<sup>3</sup> *Miller vs State* 9 Okla. R. 255

<sup>4</sup> *Koske vs D. L. & W. Ry. Co.* 142 Atl. R. 43

<sup>5</sup> *Lambertson vs Consolidated Traction Co.* 60 N. J. R., 452

<sup>6</sup> *State vs Gruch* 96 N. J. R. 202 114 Atl. R. 547

not be brought by the court in vindication of public justice, and it is for the solicitor to consider whether a bill should not be laid before the grand jury for indictment for perjury in view of the intimation by the defense in this trial that A. M. Davis was unduly benefited by the too favorable testimony of the defendant in the trial of the action against the city. The transaction is not one that the court can in justice allow to go off without investigation. Such conduct by a witness as was here described and indicated by the verdict, strikes at the very heart and root of the administration of justice. The courts cannot be too careful and scrupulous in this particular."

I do not believe that anyone will deny that the knowledge that we, as physicians, have acquired in and of our profession, is the only thing we have to sell or otherwise dispose of, in order to "support ourselves and families and contribute to the relief of" such others as we deem fit. Our knowledge is our property. It is our stock in trade, as it were. We attended schools and colleges, spent large sums of money and many years of time to acquire this knowledge, and in all honesty and equity, no one, either individual, corporation, court, or state, has or can have a lawful right to take it from us without making adequate payment for the same.

Reasoning from the foregoing premise, we contend that when any physician, surgeon, or other specialist has been called as anything except an ordinary witness, he is entitled to and should receive a fee commensurate with his standing in his profession and the service rendered in any capacity, whether it be for giving expert testimony, the performance of a difficult surgical operation, or the diagnosis of and treatment for typhoid fever, or any other medical or surgical service.

If the party to the suit, calling a physician as an expert witness, desires that the testimony of such witness be backed up or reinforced by special study or research along certain lines, special arrangements should be made beforehand and any such arrangement regarding the expert's fees

or remuneration are recoverable, if it becomes necessary for the witness to sue for the same. There are numerous decisions from State supreme courts upholding decisions by trial courts regarding the foregoing.

But when the physician enters the case as a subpoenaed witness, and is compelled to qualify and testify as an expert, without being able to collect more than the statutory mileage and *per diem* of ordinary witnesses, we feel that he has a just right to complain, and to insist that he is being compelled to deliver and give up his valuable property, in fact, all that he has to sell, without just and proper compensation.

The practice of serving a *subpoena duces tecum*, commanding a physician to appear in court at a certain time and to bring with him certain roentgenograms or other documents is a common procedure, and in far too many instances, after the presentation and identification of the roentgenograms or whatever documents are involved, the physician is compelled to interpret the roentgen findings and to give expert testimony, even to the answering of hypothetical questions. If he even so much as hesitates to do all this, he may be threatened with being charged with contempt of court, and be subject to fine or imprisonment or both. That is the rule in Illinois, and much complaint is heard against it, but with little hope of remedy or relief under present conditions. Once in a while, some of us are able by certain technicalities, to evade these sharp practices by equally sharp ones. An example of this is related in the following incident, in which the judge was against his will induced to say "*The witness does not need to answer*."

About twelve years ago one of our eminent jurists was the guest speaker at a medical meeting in Chicago. During the discussion of his presentation he was asked whether a physician subpoenaed as an ordinary witness to identify roentgenograms, could be compelled to give expert testimony, interpret roentgeno-

that it is absolutely improper and unlawful to undertake to give expert testimony on the so-called contingency basis, for a share or portion of the amount of the award of the court. There are several well-recognized decisions upon this.<sup>9 10 11 12</sup> In the case of *Matter of Shapiro*, 144 N Y App Div R, 1, an attorney was disbarred from practice because he had made an agreement with a physician wherein the latter was to receive a portion of the amount recovered, in payment for his services as an expert witness.

In *Davis vs Smoot*, 97 S E R 488, a North Carolina case in which a physician had arranged for and collected 20 per cent of the amount of the judgment, amounting to \$125 00, as expert witness fee, the witness was compelled by the trial court to immediately repay the amount of his fee, and was rightfully threatened with contempt of court action if he failed so to do. The case was appealed to the Supreme Court of that State, which court, in deciding to concur with the judgment of the lower court, suggested bringing charges of perjury and said, in part:

"These issues were submitted to the jury in this action against the physician (1) Did the defendant knowingly, designedly, willfully, and maliciously and unlawfully charge A M Davis 20 per cent of the amount recovered by A M Davis from the city as alleged in the complaint? *Answer* Yes (2) What amount, if anything, is the defendant indebted to the plaintiff? *Answer* \$125"

The defense was rested on the ground that the agreement was void as against public policy, and hence that the money having been paid, the plaintiff administrator could not recover it back. It is public policy that such a transaction as this cannot be allowed to stand simply because the

defendant has been able to enforce payment of the illegal exaction.

Besides, there was in this case evidence that the defendant physician had administered to the said A M Davis morphine and other medicines, that the latter's mind while the defendant was visiting him and giving him morphine was in a very unsatisfactory condition, and that the defendant, who "had made a very good witness," collected the \$125 with great promptness after the aforementioned A M Davis had received it.

The ground of the recovery sought by the plaintiff administrator was not that the defendant swore falsely in favor of A M Davis, but that he made representations that his testimony would be more effective if he were paid 20 per cent of the amount that the aforementioned A M Davis recovered, and after the trial he collected said 20 per cent out of the client over and above the fee of \$10 allowed by the court.

"This court will not only not enforce a contract of this kind, but will compel repayment when collection has been made and there is evidence that the party making payment was under treatment and also under the influence of morphine administered by the defendant until after the money was paid him, and that thereafter when his physician was changed the patient's mind improved, and he made an effort to secure the return of the money.

"On the verdict on the first issue, that the money had been 'designedly, willfully, maliciously, and unlawfully collected by the defendant,' the court very promptly gave judgment for its return. No court in a proper sense of its own dignity and of purity in the administration of justice, which should always be above suspicion, could permit such a transaction to stand, simply because the offender had been quick enough to secure payment before proper action could be taken.

"The defendant on the verdict was guilty of gross contempt of court. It is commended to the consideration of the court below, whether, on the evidence in this case, proceedings in contempt should

<sup>9</sup> *Clifford vs Hughes* 139 App Div R (N Y), 730, 124 N Y Supp 478

<sup>10</sup> *State vs First Bank of Nickerson*, 184 Neb R, 163, 207 N W R 674

<sup>11</sup> *Miller vs Anderson* 183 Wis R 163, 196 N W R 869 34 A L R, 1529

<sup>12</sup> *County of Campbell vs Howard* 113 Va R, 19, 112 S E R 876

a well known physician, was subpoenaed by the city. He testified that he had practised as a physician and surgeon in Springfield for the past twenty-five years, that he was a surgeon for five railroads, that he was a graduate of regular schools of medicine, and that he had been doing general surgery for the past eighteen years. He was then asked an hypothetical question, the import and contents of which do not matter here.

The Doctor declined to answer, giving as his reason that an expert witness is entitled to a different and greater compensation than an ordinary witness, that he is not required to give expert testimony unless a reasonable compensation be paid or provided for. He stated, "A reasonable fee for an expert or professional opinion in this case is \$10 00. I have not been paid nor offered anything for compensation for my expert or professional opinion in this case, nor has said compensation been in any way promised to me or provided for. On the contrary, it has been refused. Therefore, I decline to testify until such fee is provided for."

It was conceded that the witness knew nothing about the facts of the case, and was called as an expert only. It was also conceded that the charge of \$10 00 as a fee, if a legal one, was very reasonable, but it was claimed that the city had no means provided for paying such fee, and had consequently not promised to pay the same.

The Doctor, in reply to another request from the court, again declined to answer because he had received no fee nor any promise of a fee as an expert. Thereupon the court informed him that he was not entitled to receive any such fee, but that it was his duty to testify as an expert witness. The witness further stated that he was not willing to testify, although informed by the court that it was his duty to do so, and continued to refuse to answer the question.

The clerk of the court was then directed to docket a case against the witness for contempt, and the court stated to the Doctor that it was the order of the court

he should answer the question, but he still declined to do so. Thereupon, the court found him guilty of contempt and for such contempt fined him \$25 00. This order fining the witness was excepted to by his counsel, who made a motion for the remission of the fine, which motion was overruled by the court. Exception was taken to the overruling of the motion and an appeal was made to the Appellate Court.

The Appellate Court of the Third District of Illinois affirmed the decision of the Circuit Court and upon appeal to the Supreme Court, Justice Magruder of that body delivered the following opinion:

"The question in this case is, whether a physician, who has been subpoenaed and is interrogated as an expert witness only, can be punished for a contempt for refusing to testify, when no compensation, greater than that allowed to an ordinary witness, has been paid to him or promised to him.

"The question involved has never been directly decided by this court.

"It follows that, in this case, the court could not fix a compensation to be paid to appellant, nor order his fee of \$10 00 to be taxed as costs, or order that the party calling the witness pay or secure his compensation. It is claimed, however, that in a civil suit a witness who is called to testify as an expert only, should not be punished for contempt in refusing to testify because no compensation is provided for his professional opinion other than the ordinary witness fees. The power to compel the production of testimony, necessary to the decision of issues involved in pending lawsuits, is one of the rights and powers, which is inherent in the very organization of courts of justice. Contempt of court is a disobedience of the rules or orders of the court, which interferes with the due administration of the law (3 Am and Eng Ency of Law, p 777). The refusal of any witness to answer any question, which he may be lawfully required to answer, is a contempt of court, and if he persists in his refusal he may be punished accordingly (Samuel vs People, 164 Ill., 379).

grams, and answer all questions, without being paid an expert's witness fee

The learned judge very emphatically informed those present that, if they failed to answer all questions propounded to them as witnesses, in his court, they would be in contempt of court and if they persisted in refusing to answer, they would be fined or imprisoned

Some six or seven years later, a roentgenologist was summoned into the court presided over by this really eminent jurist, by means of a "*subpoena duces tecum*," after having been paid the statutory \$1 25 witness fee. After this witness had presented and identified the roentgenograms, he was asked to interpret them. This he did, not because he wanted to do it, but because he knew that he could and would be compelled to do so.

After the interpretation of the roentgenograms one of the attorneys propounded an hypothetical question to the witness. This the witness declined to answer. The attorney promptly appealed to the judge to compel the witness to answer and His Honor as promptly said, "The witness will answer." Witness replied that he could not answer the question, whereupon the judge insisted that he answer the question or be declared in contempt of court.

Looking the judge squarely in the eyes, the witness said, "Your Honor, if I answer that question, I will have to perjure myself, and if you insist upon me committing perjury, I will have to insist that you promise me your protection against the charge of perjury."

Glaring at the witness, the now decidedly irate jurist said, "The witness does not need to answer," and the witness was excused.

The procedure necessary to accomplish this is simple and effective. It has been used by a few men whom I have instructed.<sup>13</sup>

While it is true that in many States qualified witnesses may be compelled to

give expert testimony at the same *per diem* and mileage as are paid to ordinary witnesses, quite a few States have statutory and other enactments and court rules giving the courts power and authority to award additional compensation for those giving expert testimony if the same is deemed advisable.

In Pennsylvania, the law authorizes district attorneys and other officers of the court to incur expenses for the investigation of crime which can be added to the costs of the prosecution. This provision has been applied for the purpose of retaining physicians to testify whether or not arrested motorists were intoxicated. In New York, Indiana and a few other States, witnesses need not give expert testimony unless these are paid fees adequate to the value, as we see it, and it has been decided that expert witnesses may collect adequate, just fees when, as, and if they render such services.

In other States the court or court officers have certain inherent rights—or assume such rights—which while not specifically authorized by law, enable them to incur expenses for investigation necessary to aid in justly deciding any case, either criminal or civil, and in that manner enable the courts to award to expert witnesses extra compensatory fees for their expert services, in addition to the ordinary *per diem* and mileage.

The writers of text-books differ considerably in their opinions and pronouncements upon this subject, and unfortunately most courts and jurisdictions follow the rules laid down by those who hold and contend that the refusal of any witness to answer any question which he may lawfully be required to answer, is a contempt of court, and if he persists in his refusal, he may be punished accordingly.

A case decision which has been rather widely quoted, and aroused considerable interest, will be excerpted for the benefit of interested readers.

A woman sued the City of Springfield, Illinois, and the trial came up in the Circuit Court of Sangamon County. Dr. Dixon,

<sup>13</sup> If any radiologist desires the particulars he may have them by sending a stamped addressed envelope to the writer.

State without compensation. It makes no difference whether it is to be taken for the good of the public or for the benefit of a private individual, as far as the right to compensation is concerned. It is true that private property cannot be condemned by the State for a private purpose. Private property can be taken only for a public purpose. But in either case, it must be paid for. To concede, therefore, that in a criminal prosecution conducted by the State, a physician may be required to testify without compensation because it is for the public good, is to concede that his knowledge may be made use of by a court of justice without his being paid therefor. We conceive, however, that it can make no difference whether the suit in which the witness is called to testify is a suit between private parties or is a suit between the State and an alleged criminal. In either case the object is to promote public justice. It is just as important to the peace and good order of society that private controversies should be settled upon correct proofs and in accordance with truthful testimony, as that criminals who violate the laws of the State should be punished. It is the duty of the ordinary witness and of the expert witness to testify to the facts within their knowledge, which bear upon the decision of controversies in courts. Such duty devolves upon each citizen, and in view of the protection which he receives from the laws of the country in the matter of his personal liberty, and in the matter of the protection of his property. The duty devolves as much upon a physician who is required to testify as an expert witness in answer to hypothetical questions as it does upon ordinary witnesses testifying to facts within his knowledge.

"In *Vise vs County of Hamilton*, 19 Ill., 78, we held that an attorney appointed by the court to defend a criminal could not recover for his services from the county in which the prosecution was conducted, and that a court might compel an attorney, as one of its officers, to defend a prisoner in case of his inability to employ counsel.

It has never been supposed, that to require the performance of such professional services without compensation was the taking of property without compensation.<sup>14</sup>

"If the precedent is once established that expert witnesses must be paid reasonable compensation for their testimony, then it will not be long before such testimony will be offered to the highest bidder. The temptation will be to give opinions in favor of that party to the suit who will pay the highest price. The testimony of expert witnesses will soon become partisan and one-sided. The theory upon which such witnesses are required to testify in cases like this is that they are *amici curiæ*, and that testifying under the sanction of an oath, they do so not with the intent to take the part of either contestant in the suit, but with a view of arriving at the truth of the matter and for the purpose of aiding the court to pronounce a correct judgment. In *Redfield on the Law of Wills* (p. 155, Sec. 51, note 46) it is said: 'It being merely a matter of conventional arrangement between the professional experts and those who desire to employ them as witnesses both in regard to their acting as such, and also to their making preparations to enable them to give their testimony, it virtually places a price upon such testimony in the market, and its price is likely to range somewhat according to its ability to aid one or the other parties litigant. The tendency of this is to render it partisan and one-sided, as a general thing.'

"Moreover, if a physician is to be allowed extra compensation as an expert witness, then men pursuing other occupations which require expert experience will have the same right to demand extra fees. A banker will claim that he has earned extra compensation, a merchant will make the same claim, and so with men engaged in other branches of business. It will be easy to say in such cases that

<sup>14</sup> AUTHOR'S NOTE. To bring the analogy a little closer may we not say that it would most assuredly be supposed that to require such professional LEGAL services in a CIVIL suit without compensation, would be the taking of property without compensation.

"The grounds upon which the right to such extra compensation on the part of expert witnesses has been sustained, have generally been three in number. The first ground is that the time of the expert witness is more valuable than the time of ordinary men, and that, by attendance at court to give his testimony such witness meets with a loss of time. The better and more recent authorities, however, both in England and this country, now unite in the view that the right to such extra compensation cannot properly rest upon loss of time as a basis. Manifestly the witness who goes to court and testifies as to facts of which he knows is subjected to a loss of his time as much as a witness who goes there to testify as an expert upon a mere matter of opinion.

"The second ground upon which the claim for such extra compensation is based is, that the skill and accumulated knowledge of the expert are his property, and that a man's property should not be taken without just compensation. Various definitions have been given of property. Webster defines property to be 'the exclusive right of possessing, enjoying and disposing of a thing.' Blackstone says 'Property consists in the free use, enjoyment and disposal of one's acquisitions without any control or diminution, save only by the laws of the land.' It has also been said that property in its legal sense is not the thing itself, but certain rights in and over the thing, these rights being (1) user, (2) exclusion, (3) disposition. This court has also said in discussing the right to make and enforce contracts as being excluded in the rights to acquire property, that the laborer has the same right to sell his labor, and to contract with reference thereto, as has any other property owner. Labor is defined by Webster to be 'physical toil or bodily exertion,' and also to be 'hard muscular effort directed to some useful end, as agriculture, manufactures and the like.' He also defines labor to be 'intellectual exertion, mental effort, as the labor of compiling a history.' It is not exactly accurate to say that the more abstract knowl-

edge, acquired in the study of a special employment, is of itself property. It is the right to apply that knowledge to the accomplishment of a particular result which constitutes property. For instance, if the appellant had been required to answer a question put to him with a view of prescribing a remedy for the relief of Mrs. P—, the plaintiff in the suit in which he was called to testify as a witness, then it might be said, if he was not offered any compensation, that he was deprived of a property right. But when a physician is asked an hypothetical question, and is called upon to give his opinion upon the facts stated in the hypothetical question while he is testifying as a witness in court, he is not thereby required to practise his healing art, he is merely making a statement, not for the purpose of effecting a cure or relieving a patient, but for the purpose of enabling the court and the jury to understand correctly a case, which is before the court. There is no infringement here of a property right. It may be conceded that in a certain sense, the knowledge of the physician, acquired by special study, is property, but the question here is, not so much whether certain knowledge is property, as whether the requirement that he shall answer an hypothetical question is a taking of his property. Where he is required to make an application of his knowledge to a particular case so as to secure a particular result, such as, for instance, the curing of a disease or the healing of a wound, then he would undoubtedly be entitled to compensation. Counsel for appellant state that many of the cases which have held that expert witnesses can be required to testify without being paid are criminal cases, where the interest of the State and the interest of the public demand of the physician that he should yield up something of his knowledge for the benefit of society at large. This position, however, is inconsistent with the contention that when an expert witness is required to testify without compensation, his property right is interfered with. A man's property cannot be taken from him by the



"For the reasons above stated we have arrived at the conclusion that the judgments below were correct. Accordingly, the judgments of the Appellate Court and of the Circuit Court are affirmed."<sup>16</sup>

From the above-excerpted decision, we learn that we can be punished for contempt, if we refuse to answer questions of any and all kinds, as ordinary or as expert witnesses, when we are on the witness stand in Illinois and probably other States in this vicinity. But this is only partly true, because sometimes the presiding judge says, "The witness need not answer," as previously related.

While it may be an instance of a "fool venturing where angels fear to tread," I cannot help saying that evidently the Supreme Court of this State feels that we are not practising medicine unless we are prescribing for patients, when it said in the foregoing decision "If the appellant had been required to answer a question put to him with a view of prescribing a remedy for the relief of Mrs. P——, the plaintiff in the suit in which he was called as a witness, then it might be said, if he was not offered any compensation, that he was deprived of a property right." How different our methods of ratiocination must be from those distinguished justices of our Supreme Court! We, who daily give so much of our time, knowledge, and services in the treatment of the indigent sick and suffering, are, according to the learned gentlemen just mentioned, giving property away, but when that same identical knowledge is taken from us, against our will and without payment, it ceases to be property and becomes as free as the air we breathe. If that kind of reasoning were not so tragic, it would be funny. Certainly it is ridiculous, and almost certainly if that case had been carried up to the United States Supreme Court, it would have been reversed, because at that time our good friend, the late William Howard Taft, was on that high bench, and would have seen just a little more from our aspect than did others.

According to the way this last decision was reasoned out, it would be robbery, if a man took another's money by force, if the robber intended to and did use the money to buy cigars or perhaps pay a Doctor's bill, *but*, if he intended to (and perhaps did) pay his pal's fine or defray the expenses of his brother's trial for murder, it would not be robbery. The analogy is not so very unlike, is it? Or is it our fault, in that we do not know how to reason correctly regarding this matter? If it is the latter, and we do not know how to reason it out, I, for one, do not want to learn how to think that the knowledge of the medical profession, acquired by the many years of toil, study, research, etc., is not property, as much as anything can be. And furthermore, I propose to resist the taking of that property from me, without just compensation, as long as I am able to fight.

Because of the variations and differences in the prevailing laws and practices relative to the payment of witnesses who render expert testimony, it has become the custom to have the expert witnesses paid by the litigants, particularly in civil suits. However, as previously indicated, several States by express statutes provide for payment of special or extra fees to expert witnesses, the amounts of such extra fees being in some States left to the discretion of the court, while in several of these States provisions for authorizing the district attorneys to procure the services of expert witnesses in criminal cases, and to obligate the county to pay reasonable compensation for same, are in operation.

It must be understood that when one of the litigants employs a witness to give expert testimony, the fees for such witness cannot under any circumstances be included in the court costs of the trial of the case, and be reimbursed for, if the opposite side of the suit has to pay the costs of the litigation. The fees which are paid to expert witnesses cannot be recovered from the adverse party in the suit, but must be borne by the party calling the witness, irrespective of the outcome of the trial.

<sup>16</sup> Dixon vs. People, 168 Ill. R., 179



the testimony called for is the result of special knowledge and acquired skill and, therefore, should be paid for. Almost every lawsuit involves testimony which is in the nature of opinion in addition to testimony which speaks of the mere facts within the knowledge of the witnesses.

"Counsel for the appellant also claim as a third ground, that the accumulated knowledge and skill of the expert witness, if not as property, yet is 'particular services'. This contention is based upon the reasoning of the court in *Buchan vs State*, 59 Ind, 1, which is the leading case upon this subject in opposition to the views here expressed. That case proceeds mainly on the ground that the services called for are included within 'particular services' as these words are used in the Constitution of Indiana. Section 21 of the Indiana Bill of Rights provides, 'No man's particular services shall be demanded without just compensation'. The Indiana court there held that the services of an expert witness were 'particular services' and that, therefore, under the Constitution they should be paid for. No such provision as the one referred to as being contained in the Constitution of Indiana exists in the Constitution of Illinois. Counsel for the appellant say, however, that Article 2 of the Ordinance of 1787 provided. However this may be, the Ordinance of 1787 is not in force in the State of Illinois.

"The decision in *Buchan vs State*, *supra*, was rendered by a divided court consisting of five judges. Two of the judges, Chief Justice Biddle and Judge Niblack, dissented from the opinion in that case. The views of the dissenting judges are given in the case of *Dills vs State*, 59 Ind, 15, and the reasoning there is cogent and convincing, and the opinion adopts the views of the Supreme Court of Alabama as announced in the case of *Ex-parte Dement*, 53 Ala, 389. The latter case is the leading case in this country in favor of the views herein expressed, and its line of reasoning is substantially adopted in what has been here stated. That case holds

that the law allows no excuse for withholding evidence which is relevant to the matters in question before its tribunals, and is not protected from disclosure by some principle of legal policy,

"Upon this subject, Rogers, in his able and exhaustive work on *Expert Testimony* (Sec 188, p 424, 2nd ed), says, 'There can be no doubt that professional men are not entitled in this country to claim any additional compensation, when testifying as ordinary witnesses to facts which happened to fall under their observation. But another question arises, when they are summoned to testify as to facts of science, with which they have become familiar by means of special study or investigation, or to express opinions based upon the skill acquired from special researches as to conclusions which ought to be drawn from given facts. Whether they can be compelled to testify in such cases, when no other compensation has been tendered than the usual fees of ordinary witnesses testifying to ordinary facts, is a point upon which the cases are not in harmony. In this country, the cases are nearly balanced, and the question must be regarded as still an open one, although the weight of authority rather inclines to the theory that the expert may be required to answer the question without additional compensation'. As has already been stated, we prefer to adopt the views announced by the Supreme Court of Alabama and in the cases following the Alabama decision.

"We cannot close this opinion without quoting and endorsing the following views expressed by the Texas Court of Appeals in *Summers vs State*. 'It is to be regretted, that a member of a profession with so distinguished and high sense of honor and duty should refuse to testify in a case pending before the courts of his country, involving the life of a fellow being, and the rightful administration of the law of a common country. Dr Spohn has doubtless been misled in taking the position he did by the misconceptions of certain writers on jurisprudence'.

much upon the geographic location of the trial at which the testimony is given, the distance travelled by the witness, the seriousness or gravity of the case, whether it involves a hundred dollars or a hundred thousand dollars, the length of time that the witness is on the stand (if local) or away from his office (if distant), and last, but by no means least, the standing and reputation of the witness himself

"I would say that in a city the size of yours, when called as an expert witness and not more than one hour is consumed, a fee of \$25 00 should be the minimum. If a half day was consumed, it should not be less than \$50 00, while if it was a very important case in which a large amount of money was involved, and the expert's testimony was one of the critical points upon which either the decision or the amount of the verdict hinged, the fee should not be less than \$100 00, and from that up. If a specialist has to go to some other city or town, the fee should be not less than \$50 00 per day and expenses, if within the same county, and relatively more outside of the county. For the same service at greater distance, the fee should be approximately \$100 00 per day

and expenses, except when or where the outcome of an important case hinges on and depends in a large measure upon the expert's testimony, in which event I have advised—and charged—up to \$500 00 per day, and do not consider that amount excessive in suitable instances. Of course, the latter sort of cases are rare, but we must be prepared to embrace such opportunities when they present themselves. I received the latter fee just once, but my services were worth that much or the people who had me come five hundred miles would not have been willing to pay it.

"Trusting that this will give you my ideas relative to the matter, and that you will be able to boost your fees much over the four-dollar mark, which to me appears to be ridiculously inadequate for an expert witness," etc.

While the foregoing is merely "a drop in the bucket" as regards what we might write relative to this broad subject, we sincerely hope that this contribution will add a "wee bitty" to what we should know regarding expert testimony.

*(To be continued)*

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Quite a considerable number of suits to recover fees due expert witnesses have been decided, almost always in favor of the expert witness. A recent New Jersey case<sup>16</sup> is particularly interesting. The plaintiff in this case (a roentgenologist and member of this Society) had been employed by the attorney for a woman who was suing for damages in a personal injury case, and had rendered services as an expert witness, the roentgenologist rendering a bill for \$100 for his fee. The woman claimed that, not having personally contracted for his services, she was not obliged to pay. Dr. Klein brought suit and at the trial, the judge took the case from the jury on the ground that no case had been made. The Doctor then appealed to the New Jersey Supreme Court.

The Supreme Court of New Jersey said, in effect, that

"An attorney has no authority under his retainer to surrender or waive without the consent of his client any substantial legal right. But when the defendant's attorney obligated his client to the extent of \$100, he did not surrender or waive any of his client's substantial rights. His act was that of a careful and prudent attorney, to protect and promote his client's interest. It is common knowledge that, when one has sustained serious injuries, roentgenograms are frequently made by experts to determine the nature and extent of such injuries, that an expert is necessary (*sic*) to interpret such roentgenograms, and that it is the common practice to use the testimony of such experts, whenever available, in a suit to recover damages for such injuries. Further, if the propriety of a challenged expenditure for which the defendant denied liability is to be judged by the result obtained, the defendant's failure to challenge either the necessity of the expert testimony given or the reasonableness of the fee charged is readily understood, in the case in which such testimony was given, the defendant in this case, who was the plaintiff there, recovered a verdict of \$15,000.

"It is far from a mere conjecture that, if the attorney had failed to produce this expert testimony—and he could not produce it unless it was volunteered, without arranging for the payment of the expert—he might well have subjected himself to a claim of negligence, at the suit of his client. The Supreme Court is of the opinion, therefore, that an attorney who is retained to prosecute a suit for damages arising out of an accident has implied authority to obligate his client to pay the fee of an expert witness whom he employs to testify in behalf of such client, when the necessity for such a witness and the reasonableness of his fee are not challenged.

"Accordingly, the judgment of the district court, withdrawing the case from the jury, is reversed and the case remanded for trial."

The foregoing apparently solves at least one problem relative to the fees of expert witnesses. Parties to personal injury damage suits are liable for the fees of expert witnesses, if the services of the witnesses are contracted for by the attorney of the aforementioned party to the suit.

#### THE AMOUNT OF EXPERT WITNESS FEES?

In February of this year a radiologist in a city of about 43,000 population, in a central State, wrote me "I want to thank you for the effort you have made to educate your fellows concerning the rights and good practices of radiologists in medico-legal cases.

"It so happens that I am often called to testify as an expert witness and for this I have received the grand sum and total of \$4.00 a day.

"Will you kindly let me know what you consider a fair charge in an average case, testifying as an expert witness? I understand that this would vary with the case, but I wish to have a figure from which to vary."

My reply was "Re fees for radiologists (or other physicians) who give expert testimony, will say that that depends very

<sup>16</sup> Klein vs. Boylan 179 Atl. R. 638

ported (2, 4, 12, 17) in which the intussusception had been present for two weeks and longer without the production of gangrene

acerbations Generalized abdominal pains of a colicky nature are more often complained of than acute sharp pains Nausea



Fig 1 Spot" roentgenogram made with fluoroscopic unit Site of intussusception and tumor before reduction, which is just to the left of the mid line in the transverse colon

or obstruction Whether due to increased tolerance of the bowel to reduced nutrition, to gradual stretching of the mesentery and vessels, to increased mobility of the bowel and mesentery, or to marked dilatation of the intussuscepiens has not always been determined

The symptoms produced by these chronic or recurring forms of intussusception are indefinite and irregular Gradually increasing constipation, which may be interspersed with periods of diarrhea, is frequently found Blood in the stools is uncommon but may be found in acute ex-

is sometimes present, but vomiting is rare Gradual loss of appetite and some loss of weight and strength is common The presence of a mass in the upper abdomen or in either side is relatively common, but it may be very transitory Anemia is more often produced by malignant tumors associated with intussusception than by intussusception primarily Other laboratory findings are not definitely characteristic

The roentgenographic appearance of intussusception was first described by Lehman Groedel, Snow, and Edburg have added to our knowledge of this subject

# CHRONIC RECURRENT INTUSSUSCEPTION IN AN ADULT ASSOCIATED WITH ADENOCARCINOMA OF THE CECUM

## A CASE REPORT

By E L SHIFLETT, M D, *Louisville, Ky*, and B KALAYJIAN, M D, *Indianapolis, Indiana*

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**A** REVIEW of the available literature reveals that only 20 per cent of all intussusceptions occur in patients over two years of age, and only 5 to 10 per cent in adults. The acute form is rare after puberty, and most chronic cases are found in patients from thirty to fifty years of age. There is a definite predominance in males, the ratio given being from two to three males to one female (8, 10).

Tumors are frequently found associated with, or as the causative factor in adult intussusceptions. Mayo (10) states that 85 per cent of all adult intussusceptions are produced by tumors, and further that 67 per cent of these tumors are malignant. Other authors (8, 13, 15) stress the fact that benign tumors, particularly of the small bowel, are more common than has been previously reported, and that they are frequently associated with intussusception.

Other causes of intussusception in adults are given as tuberculous and other infectious processes of the bowel, inverted appendix, inverted diverticulum, Meckel's diverticulum, anatomic and pathologic variations in the mobility of the cecum and ascending colon, irregular peristalsis, and unusual muscular effort.

The relationship between the presence of a tumor in the bowel and intussusception is not entirely clear. The prevailing theories are as follows:

(1) That the tumor acts as a foreign body, particularly if pedunculated. The bowel produces violent peristaltic movements in its attempt to dislodge the tumor, and, in pushing the tumor mass distally along the bowel lumen, the attached bowel wall is pulled along with it, inverted, invaginated, and propelled into the distal portion of the bowel by the violent peristaltic movements.

(2) That the weight and mass of the tumor itself may initiate the process, and then it is aided by peristalsis.

(3) That in those cases in which the tumor is some distance proximal to the head of the intussusceptum, there has been a constriction of the bowel about the site of the tumor and a relaxation distally, so that in ordinary peristaltic action the entire segment is thrust forward into the distal loop.

(4) That there is sometimes perverted muscular action due to the presence of the tumor, and simple relaxation or paralysis of the bowel by the tumor.

(5) Finally, that in malignant disease of the bowel, the infiltration of the bowel wall by the malignant process, with resultant loss of elasticity and contractile powers, makes invagination of a more flexible proximal segment relatively easy.

The essential pathology of intussusception is that of restriction of the blood supply to the involved segments of bowel. The mesentery carrying the blood vessels to the bowel walls is constricted by the invagination. The veins are first occluded by this constriction, producing venous stasis but permitting arterial flow. The involved segments of bowel become edematous, particularly the middle and inner layers. The edema of the bowel results in further constriction of the mesentery, and finally the arteries are also occluded. There is an infiltration of blood and mucus into the lumen and a transudation of bacteria through the bowel walls into the peritoneum. Necrosis and gangrene of the involved bowel follow, though the outer layer is less likely to be so involved than the middle and inner ones.

This sequence of events is apparently not always found in chronic or recurring types of intussusception. Cases have been re-



Fig 2

Fig 2 Colon filled after reduction of intussusception. Note spasm and irregular contractions of the cecum. Tumor is not demonstrated. Colon dilated distal to location of intussusception.



Fig 3

Fig 3 Roentgenogram taken after evacuation of barium enema. Irregular and fibrillary contractions of that portion of the colon involved by the intussusception. The arrows localize the farthest progression of the intussusception and deformity of cecal wall near the tip. Small tumor mass could be observed fluoroscopically because of displacement of barium.

the transverse colon which could be forced into the cecum. No definite diagnosis of intussusception was made at that time, although we believe that an intussusception must have been present, in view of the later findings. The mass disappeared at that time, as it had done repeatedly in the previous months, but returned in a few days and had been constantly present from that time until admission without evident change in the symptomatology.

In our examination of the colon by barium enema, we found the enema obstructed in the transverse colon just to the left of the mid-line (Fig 1). The obstruction was produced by an apparent intraluminal mass, which was shown by manipulation to fill the entire lumen. The mass was round, smooth, and showed nothing like the typical U-shaped deformity which one would expect to find in an intussusception.

By using pressure behind the mass, it was readily moved from its original site in the transverse colon to the lower pole of the cecum (Fig 2). It was found to be a single mass, smooth in contour, about the size of a small orange, and apparently attached only loosely, if at all, to the bowel. Frequent mass peristaltic movements appeared during the course of the examination. These movements always originated at the temporary site of the mass, and the patient complained of slight pains when these movements occurred. The bowel distal to the point of obstruction was dilated. No evidence of a pedicle to the mass could be made out, although on one film there was a suggestive strand of increased density which seemed to be attached to the inferior surface of the mass and connected with the bowel wall near the ileocecal valve. The tumor could not be pushed through the

Rutledge (16) and others have recently added extensive observations. In the ileal, or enteric type the barium enema is of no value except for exclusion of colonic involvement. In the ileocecal type, the head of the intussusceptum may pass far into the colon, with dilatation of the colon distal to it, and loss of normal haustral markings. In this type, the typical U-shaped deformity at the point of obstruction of the barium enema can usually be made out. In the ileocolic type, the primary invagination begins in the ileum, and it does not often extend so far into the colon. At times, the barium enema may be seen to pass between the layers, as the intussusceptum—largely the ileum—is smaller than in other types. The colonic form produces a similar appearance to that of the ileocecal form, although tumor of the colon has quite often been reported (16).

The successful and permanent reduction of some cases of intussusception by barium enema alone has been reported (16). Many authors feel it should be tried before surgery is resorted to, but the majority of cases require surgery after the diagnosis has been made. Mayo (10) believes resection to be the procedure of choice in chronic intussusception, since he has found such a high percentage of malignant tumors to be the causative factors in these cases.

We believe the following case is of interest and importance because of these facts.

There is an atypical history of malignancy even after prolonged observation, during which time no definite diagnosis had been made.

The intussusception recurred at intervals over a period of eight months, without producing obstructive symptoms at any time.

The intussusception was undoubtedly completely reduced at one time under the fluoroscope by another roentgenologist, and then returned shortly thereafter. It had been present without change in outward appearance or symptoms for over four weeks at the time we first saw the patient.

The intussusception was even then so easily reduced under the fluoroscope, that the

usual adhesions between the bowel walls that form under such conditions in much less time could not have been formed in this case.

And finally, the type of mass or violent peristalsis that is believed by many to be a vital part in the production of intussusception in cases in which a tumor of the bowel is present, was observed under the fluoroscope.

#### CASE REPORT

Mrs. C. P., aged 69 years, was admitted to the hospital on Aug. 27, 1935, with the following complaints: Generalized abdominal distress at intervals, without severe pain at any time, for a period of eight months, slight constipation which seemed to be gradually increasing, slight loss of weight and appetite, and a peculiar irregular and often transient sensation of a mass, or "drawing sensation" in the right side of the abdomen.

There seemed to be no relationship between the indefinite pain and eating or bowel movements. There had been no nausea, vomiting, blood or mucus in the stools, diarrhea, chills, fever, urinary symptoms, referred pain, rash, or other manifestation of infection. The symptoms had developed gradually over a period of eight months, during which time she had been seen by a physician, but no definite diagnosis had been made.

Physical examination revealed little of significance other than a definite mass in the upper abdomen just to the left of the mid-line. This was rather firm, smooth, rounded, and somewhat tender to deep palpation. It could not be dislodged from its position by external palpation alone.

There was a mild secondary anemia with an erythrocyte count of 3,930,000 and hemoglobin of 78 per cent—12 grams. The urine was essentially normal and the kidney function was within normal limits. A stool examination was not made.

A roentgenographic examination of the colon had been made in another city six weeks prior to admission here. The diagnosis then made was of a movable mass in



Fig 2

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Fig 3

Fig 3 Roentgenogram taken after evacuation of barium enema. Irregular and fibrillary contractions of that portion of the colon involved by the intussusception. The arrows localize the farthest progression of the intussusception, and deformity of cecal wall near the tip. Small tumor mass could be observed fluoroscopically because of displacement of barium.

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In our examination of the colon by barium enema, we found the enema obstructed in the transverse colon just to the left of the mid-line (Fig 1). The obstruction was produced by an apparent intraluminal mass, which was shown by manipulation to fill the entire lumen. The mass was round, smooth, and showed nothing like the typical U-shaped deformity which one would expect to find in an intussusception.

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ileocecal valve, nor could barium be expressed into the terminal ileum (Fig 3)

In attempting to come to a logical conclusion from our findings, we considered seriously the possibility of this being a recurrent intussusception or fecalith. We felt, however, that the length of time the mass had been constantly present without change in symptoms, the lack of typical findings, the ease with which the mass could be moved about, and the suggestive appearance of a pedicle made the diagnosis of intussusception highly improbable. We also considered the possibility of this being a malignant tumor, but felt that there should have been more definite anatomic changes with such a long history. We concluded, therefore, that the mass was probably a benign tumor on a long pedicle. We were unable to determine whether the primary origin was in the cecum or terminal ileum.

At operation, immediately after our examination, the intussusception was not present, but the appearance of the bowel indicated to the surgeon that one had been present. It undoubtedly had been reduced under the fluoroscope pre-operatively. The appendix, cecum, and ascending colon were shortened and thickened. A tumor with a broad base could be felt inside the cecum. A resection of the cecum, ascending colon, and terminal ileum was done, and an anastomosis between the ileum and hepatic flexure was completed. Recovery from the operation was uneventful.

The pathologic report on the specimen stated that it was an annular papillomatous type of adenocarcinoma of the colon, located immediately around the insertion of the appendix. It measured six centi-

meters in its greatest diameter. There was no definite involvement of the neighboring lymph nodes.

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# ROENTGENOLOGIC STUDY OF SACROCOCCYGEAL CHORDOMA

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CHORDOMA is a rare tumor which arises from the cellular vestiges of the embryonal notochord. It occurs most frequently in the spheno-occipital and sacrococcygeal regions, but primary chordoma has been reported to occur in other parts of the spinal column and the skull. Recently Stewart (1, 2, 3), Andler (4), Montgomery and Wolman (5), Hass (6), Adson, Kernohan, and Woltman (7), and Fletcher, Woltman, and Adson (8) have presented pathologic and clinical studies of this tumor, but very little has been reported on the roentgenologic diagnosis. In the more recent publications, x-ray examination is included in a larger number of cases, and, occasionally, roentgenograms are reproduced. Opinions, however, still differ widely in the estimation of the value of roentgenologic examinations. Most authors concur in that, in the spheno-occipital region, an x-ray examination would not reveal any characteristic or diagnostic evidence other than undifferentiated destruction when it is present. This is so probably because of the complexity of the neighboring dense structures and the comparatively small size of the tumor. In the sacrococcygeal region, where the bony parts are more accessible to direct roentgenologic examination and the tumor is generally larger in size when pressure symptoms are present, it is reasonable to expect that a roentgenologic examination would show more characteristic findings. In the present study, based on a review of published cases and our three proven cases, we are attempting to evaluate the roentgenologic findings of this tumor in the sacrococcygeal region.

## REVIEW OF LITERATURE

Burrow and Stewart (2), in discussing the diagnosis of spheno-occipital chordoma,

stated that a good x-ray film taken with a Potter-Bucky diaphragm might show evidence of absorption of bone or the outline of the soft tissue tumor, but, apart from the microscope, the exact pathology must remain obscure. Adson, Kernohan, and Woltman (7) found x-ray examination less helpful in the diagnosis of spheno-occipital chordoma. In one of their three cases, in spite of the fact that the tumor had originated from the region of the spheno-occipital synchondrosis and had invaded the surrounding bone, little evidence of destruction of the bone was seen in the post-mortem roentgenogram, and, in another case, in which the roentgenogram showed erosion of the upper three cervical vertebrae, the tumor behaved grossly more like a neurofibroma than a chordoma. However, in an article on chordomas of the cranium and the cervical spine, Hass (6) expressed the opinion that the clinical diagnosis of this tumor is difficult without the aid of roentgen examination or biopsy. In his case Sosman found in the roentgenograms a destructive process involving the occipital bone at the anterior edge of the foramen magnum and the arch of the atlas, there was also a large soft tissue tumor bulging into the posterior nasopharynx. Sosman gave the impression that the roentgen findings indicated a malignant process, possibly metastatic, however, he also stated that the only primary tumor in this region would be a chordoma. Hass mentioned also that the injection of iodized oil into the subarachnoid space may be of the greatest value in demonstrating the presence of an extradural tumor compressing the ventral surface of the cervical cord.

Syme and Cappell (9) reported a case of chordoma of the pharyngeal region which was illustrated with a roentgenogram showing marked destruction of the body of

the third cervical vertebra and commencing erosion of the bodies of the second and fourth cervical vertebrae Cappell (10) re-

vertebrae Halter (14) reproduced in his article a postmortem roentgenogram of the sacrum (Fig 1), showing destruction of the



Fig 1

Fig 1 Halter's case (14) Postmortem roentgenogram showing destruction of the sacrum which Halter considered as typical of chordoma



Fig 2

Fig 2 Wildbolz' case Roentgenogram of a sacral chordoma showing characteristic changes (Note expansion, vacuolation, and trabeculation of the involved bone)

corded another case of chordoma occurring in the dorsal region, with x-ray evidence of abnormality of the fifth and sixth dorsal vertebrae, the intervening disc being apparently destroyed and merged in an ill-defined mass which involved both vertebral bodies, the discs above and below these vertebrae also appeared to be thinned. Davison and Weil (11) presented a case of chordoma on the left side of the cauda equina which showed sclerosis of the left half of the third lumbar vertebra on x-ray examination.

Zollinger (12) recorded a case in which the roentgenogram showed irregularity of the outline of the third lumbar vertebra, with narrowing and increased density of the left side of the vertebral body, suggesting an old compression fracture.

Hutton and Young (13) reported a case of sacrococcygeal chordoma in which the x-ray examination showed that the lower end of the sacrum was not easily distinguishable from the tumor, and the outline of the coccyx was quite indefinite, it was thought that there was some irregular bone formation in the second and third lumbar

bone which was reported as typical of chordoma. Gerber (15) found in the roentgenogram of his case of sacral chordoma a round shadow in the pelvic cavity at the lower portion of the spinal column but without changes in the bone, this was a case of antesacral chordoma. In Key and Berven's case (16), Akerlund described changes of expansion of the sacrum with multiple, spotty areas of destruction and suggested the possible diagnosis of chordoma. Wildbolz (17), in the roentgenologic examination of the sacrum of his case (Fig 2), found changes which he considered as characteristic of chordoma, but did not describe the changes. Fletcher, Wolman, and Adson reported ten cases of sacrococcygeal chordoma, in four of which the roentgenograms gave evidence of destruction of the sacral vertebrae which, in appearance, suggested the presence of a malignant growth, in five the roentgenologic report was negative, but they suggested that with recent improvement of roentgenologic technic incidence of negative findings would probably not be so high. However, they considered that no roent-

genologic appearance diagnostic of chordoma, as distinguished from other malignant tumors, could be established and that

tients, which showed the same honeycomb appearance in the region of a hypophyseal chordoma



Fig 3 Andler's case. Roentgenogram of the sacrum showing honeycomb destruction of the bone which Andler described as characteristic of chordoma. (a, typical structure of a chordoma; b, diffuse tumor shadow; c, air bubble)

studies with iodized poppy-seed oil, 40 per cent, in the suspected cases of sacrococcygeal chordoma might produce diagnostic information before routine roentgenograms became positive. Andler (4), in his excellent article on sacrococcygeal chordoma, reported seven cases. In five, the roentgenologic findings were indicative of chordoma, one of these was illustrated by a roentgenogram (Fig 3). The characteristic findings were multiple, small and large, radiotransparent areas distributed irregularly in the diffuse tumor shadow which replaced the normal bony structure almost completely and gave a net-like, honeycomb appearance, due to the contrast of the preserved, shadow-producing bony spicules and the partition walls on the one hand, and the tumor cysts on the other hand. The distribution of the transparent areas was irregular due to the appearance of the clastic parts in the firm connective tissue tumor. Outside of the sacrum and coccyx, the tumor shadow was more uniform, yet the radio-opacity varied there in accordance with the amount of the connective tissue and cyst-like structure. Andler also noted that the findings typical of sacrococcygeal chordoma were also present in cranial chordoma as was seen in the roentgenologic examination of one of his pa-

#### REPORT OF CASES

**Case 1.** A Chinese male teacher, 42 years of age, was first seen in this clinic on Feb 28, 1933. His complaint was a tumor mass in the gluteal regions, of four years' duration. At the onset the patient had pain in both gluteal regions and a hard painful nodule about the size of a hen's egg in the right buttock. Several months later, two other masses developed at the same location, these grew and coalesced to form a large tumor. One year after the onset two new masses appeared in the left buttock which gradually increased in size and formed one large tumor with the masses in the right buttock. There was pain upon sitting. Constipation had been present for two years and frequent desire to urinate for eight months.

Physical examination showed a hard tumor mass of  $20 \times 20 \times 15$  cm, occupying the entire gluteal regions and stretching the perineum (Fig 4). The overlying skin appeared normal in color but was adherent to the mass. The tumor itself was not movable. The superficial veins were congested. On rectal examination, a mass protruding anteriorly was felt.

**Roentgenologic Examination.**—The lateral view (Fig 5) demonstrated a huge soft

the third cervical vertebra and commencing erosion of the bodies of the second and fourth cervical vertebrae Cappell (10) re-

vertebrae Halter (14) reproduced in his article a postmortem roentgenogram of the sacrum (Fig 1), showing destruction of the



Fig 1

Fig 1 Halter's case (14) Postmortem roentgenogram showing destruction of the sacrum which Halter considered as typical of chordoma



Fig 2

Fig 2 Wildbolz case Roentgenogram of a sacral chordoma showing characteristic changes (Note expansion, vacuolation, and trabeculation of the involved bone)

corded another case of chordoma occurring in the dorsal region, with x-ray evidence of abnormality of the fifth and sixth dorsal vertebrae, the intervening disc being apparently destroyed and merged in an ill-defined mass which involved both vertebral bodies, the discs above and below these vertebrae also appeared to be thinned Davison and Weil (11) presented a case of chordoma on the left side of the cauda equina which showed sclerosis of the left half of the third lumbar vertebra on x-ray examination

Zollinger (12) recorded a case in which the roentgenogram showed irregularity of the outline of the third lumbar vertebra, with narrowing and increased density of the left side of the vertebral body, suggesting an old compression fracture

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symptoms of difficult defecation and urination. Dull pain over both lower extremities had been present for about six months. Another roentgenologic examination showed changes similar to these present before, except that the sacrum appeared more expanded. Findings of expansion, rarefaction, and trabeculation were also found in the blade of the left ilium, indicating extension of the tumor.<sup>1</sup>

**Case 3** A Chinese woman, 51 years of age, was seen on Aug 1, 1933, because of pain in the sacral region, especially at night. The pain had been present for about two years and constipation for three months. Rectal examination revealed a large, smooth, round, firm mass measuring about 9 cm posterior to the rectum. The sacral region was swollen and tender. The patient could not lie flat on her back.

*Roentgenologic examination* of the pelvis (Figs 7 and 8) demonstrated moderate expansion and marked destruction of the middle and lower thirds of the sacrum. The involved area presented a lobulated appearance. There were irregular, soft, dense masses in the tumor. The outline of the growth was ill defined laterally, while its upper border was quite well limited by the uninvolved upper segments of the sacrum. With barium enema, the rectum was found to be compressed and displaced to the left side and anteriorly (Fig 9). The roentgenologic diagnosis was malignant neoplasm in the sacrum and coccyx, suggestive of chordoma. Subsequent x-ray examinations in November and December, 1933, and in February and May, 1934, showed little change in the roentgenographic appearance of the sacrum and the tumor. In April, 1935, another examination revealed an extension of the sacral involvement and suggestive evidence of pulmonary metastasis.

A needle biopsy was done, obtaining some glistening semi-gelatinous material which, on microscopic study, was diagnosed as chordoma (Fig 10).

The patient received two series of x-ray

<sup>1</sup> Case reported by Pai with complete pathologic study (18).

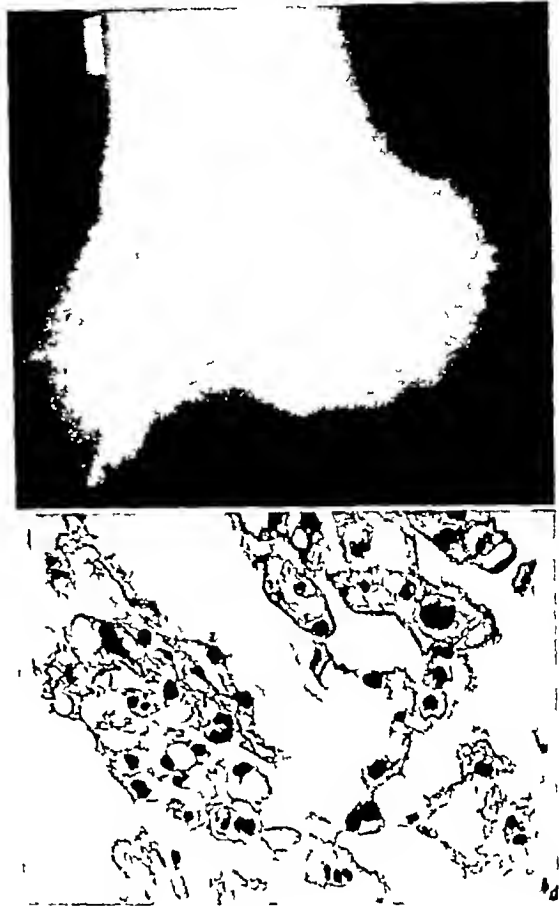


Fig 5 (upper) Case 1. Roentgenogram of the sacral tumor in the lateral view showing the destruction of the lower two-thirds of the sacrum and the structural appearance of the dense trabeculae and irregular masses in the protruding soft tissue tumor.

Fig 6 (lower) Case 1. Photomicrograph showing masses of swollen vacuolated cells with intracellular mucin and intercellular free masses of mucin deposits. Elsewhere in the section not shown in this illustration the periphery of some of the masses is surrounded by a zone of cells with elongated nuclei: the so-called 'sheath cells'.

treatments (180 kv constant potential, 8 ma, 50 cm STD, filters 56 mm oil, 0.5 mm Cu and 2 mm Al, 20 r/min, 800 r measured in air, 100 per cent ESD) from Aug 23 to Sept 20, 1933, and from Nov 4 to Nov 28, 1933, through two posterior and one perineal portals. The skin of each of the posterior portals received a total dose of 2,800 r and the perineal portal a total of 1,050 r. On Jan 20, 1934, 28 radon gold seeds containing 51.66 millicuries were inserted interstitially in the tumor.

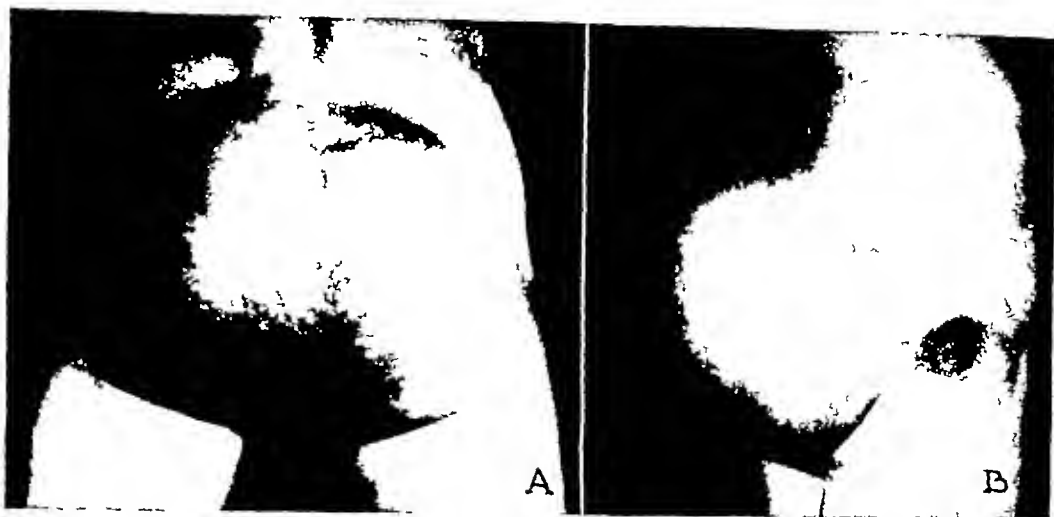


Fig 4 Case 1 Photographs of the tumor in the sacral and gluteal regions (a posterior view, b, side view)

tissue swelling in the gluteal region. The lower two-thirds of the sacrum and the coccyx were extensively destroyed. The anterior outline of these bones could be traced in places, but their posterior border was entirely absent. In the soft tumor mass, which extended mostly posteriorly, there were bony trabeculae in the upper portion and considerable irregular masses of mild density in the lower portion. The appearance of the bony trabeculae and the irregular, dense masses in the soft tissue tumor suggested a growth which had originated in the bones, destroyed them, and carried the bony fragments and debris into the gluteal mass. A roentgenologic diagnosis of chordoma was made which was confirmed by a needle biopsy and pathologic examination (Fig 6).

The patient did not return to the clinic for further consultation.

**Case 2** A Chinese male farmer, 62 years of age, came to the hospital on July 16, 1927, complaining of a large mass in the right buttock of two years' duration. He had a fall six months before the appearance of the tumor. The tumor grew steadily till it measured about  $14.5 \times 12 \times 7.5$  centimeters. The tumor was firm and fixed to the underlying bone but was not attached to the skin. The lateral border of the mass was movable and its consistency

was like cartilage in places. There was occasional pain in the tumor. Pain along the right leg had been noticed for six months. Neurologic examination showed no definite involvement of the sciatic nerve other than probably stretching. Some difficulty in defecation and urination was present. Rectal examination revealed a prominence of the right border of the sacrum.

*Roentgenologic examination* of the pelvis in the anteroposterior view showed expansion of the lower portion of the sacrum to both sides, the bone was rarefied and trabeculated. In the lateral view the outline of the involved bone could not be defined except along its upper border. The roentgenologic diagnosis was giant-cell tumor or osteochondroma of the sacrum. (Unfortunately the roentgenograms are not available for reproduction.)

An exploratory operation was done. Several finger-like projections were felt under the skin and these were found to be tumor invading the gluteal muscle. The tumor was partially removed. Upon pathologic study the tumor was diagnosed as chordoma.

The patient left the hospital with improvement of symptoms. One year later he was admitted again for study. During the interval the tumor had increased in size gradually and there was return of

symptoms of difficult defecation and urination. Dull pain over both lower extremities had been present for about six months. Another roentgenologic examination showed changes similar to these present before, except that the sacrum appeared more expanded. Findings of expansion, rarefaction, and trabeculation were also found in the blade of the left ilium, indicating extension of the tumor.<sup>1</sup>

**Case 3** A Chinese woman, 51 years of age, was seen on Aug 1, 1933, because of pain in the sacral region, especially at night. The pain had been present for about two years and constipation for three months. Rectal examination revealed a large, smooth, round, firm mass measuring about 9 cm posterior to the rectum. The sacral region was swollen and tender. The patient could not lie flat on her back.

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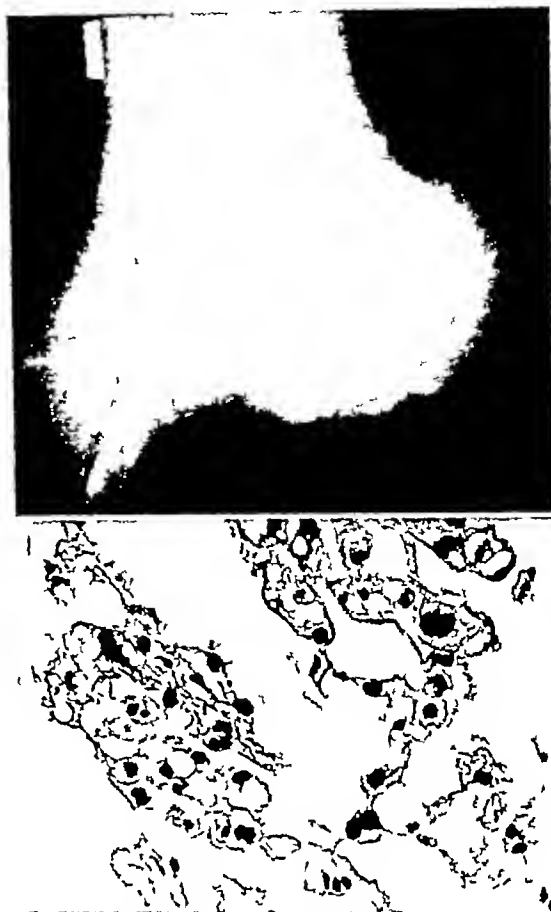


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seems to be that chordoma in the sphenoccipital and thoraco-lumbar regions does



Fig 7



Fig 8

Fig 7 Case 3 Roentgenogram of the sacral region in the lateral projection showing marked destruction and expansion of the lower two thirds of the sacrum. The outline of the end of the sacrum is entirely lost. The destroyed bone is traversed by dense trabeculae and presents a lobulated appearance. Anterior to the sacrum in the tumor there are irregular masses of dense material.

Fig 8 Case 3 Anteroposterior view of the sacrum showing destruction of the bone with the presence of trabeculation and vacuolation. The upper border of the involvement is quite well defined. The outline of the bone at the lower portions cannot be made out. Dense masses are seen in the left lower area of the sacral region.

and left in permanently, these delivered a total dose of 6,888 millicurie-hours. Following the x-ray and radon treatments, clinical examinations showed definite regression in the size of the tumor, marked relief of the difficulty in defecation, and practically disappearance of pain in the sacral and rectal regions. The patient disappeared from the clinic after a visit in May, 1934, and did not return until April, 1935, when a follow-up x-ray examination showed marked extension of the tumor into the upper third of the sacrum. Two months later there was increased difficulty in emptying of the bowels and bladder, more pain was present locally in the tumor and radiating to both thighs. Further radiation therapy was advised, but refused by the patient.

#### ROENTGENOLOGIC CONSIDERATION

From the review of the literature, it

not yield positive roentgenologic diagnostic signs except for destruction of the bone and compression of the spinal cord as shown by injected contrast medium. The destruction and compression have no intrinsic characteristic appearance. However, in Hass' case of sphenoccipital chordoma, Sosman thought that if metastatic tumor could be ruled out, the location alone would favor the diagnosis of a primary chordoma, and in Andler's case of hypophyseal chordoma roentgenologic changes characteristic of sacrococcygeal chordoma were found.

In chordoma of the sacrococcygeal region, the study of our own cases and those reported in the literature has led us to believe that there are characteristic roentgen signs. These signs are as follows:

1. *Expansion*—This may be demonstrated in the anteroposterior or lateral views, preferably by stereoscopic examina-

tion The bone is hollowed out and appears widened in one or more diameters The outline of the bone may or may not be entirely preserved

2 *Rarefaction or Destruction*—The involved bone presents either a loculated appearance with multiple small circular or oval radiotranslucent areas or the bone is destroyed in large areas

3 *Trabeculation*—The remains of the undestroyed bone form dense trabeculae which may extend into the soft tissue mass outside the original normal boundary of the bone

4 *Calcification*—This may be due to reactive new bone formation or deposit of calcified material in the tumor as a result of degeneration or necrosis This calcified matter appears usually in irregular masses of soft radio-opacity

In our three cases all or most of these signs are present In the articles by Andler (4), Halter (14), and Wildbolz (17), in which roentgenograms are reproduced (Figs 1, 2, and 3), the roentgenologic appearance of the changes is strikingly similar to that of our cases Even in Case 7 of Fletcher, Woltman, and Adson's report (8), which is the only case illustrated by a roentgenogram, the appearance of the involved sacrum seems to show the same findings, *i e*, expansion of the bone, loculation, and trabeculation Andler's description of the roentgenologic findings of his cases (4), which he believed to be typical of chordoma, agree in general with ours

In order to understand the roentgenologic appearance of chordoma in the sacrococcygeal region a review of the gross anatomic appearance of the tumor is helpful The typical chordoma is a slowly infiltrative, expanding growth, usually well encapsulated by fibrous tissue which is continuous with the narrow septum of connective tissue that divides the tumor into irregular lobules These lobules are composed of soft, mucinous or gelatinous tissue, which is semitransparent or translucent The softer portions are pale bluish-gray, while the firm opaque lobules usually indicate a more rapid rate of growth, increased

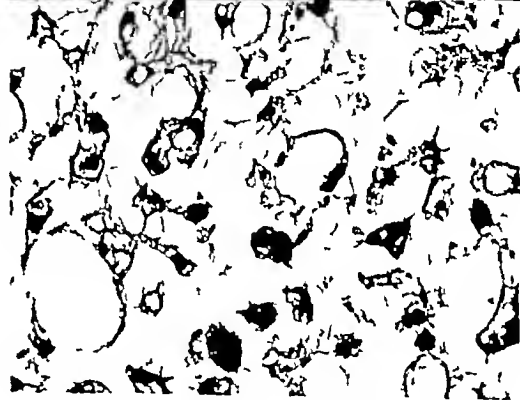


Fig 9 (*upper*) Case 3 Lateral view of the pelvis after barium enema showing anterior displacement of the rectum due to the tumor arising from the sacrum

Fig 10 (*lower*) Case 3 Photomicrograph of the tumor showing tumor cells with small and large vacuoles There is no clear-cut cell border Among the cells a large amount of homogeneous mucinous matrix is present

cellularity and a heightened tendency toward the invasion of regional tissues Foci of necrosis with hemorrhage are not uncommon Cystic degeneration with calcification is infrequent Bits of cartilage, clumps of sequestered bone, and islands of newly formed bone are observed in some instances, especially in regions in which the neoplasm is in contact with bone The invasion of bone is characterized by irregular lacunar resorption, and reactive osteogenesis is never prominent The widespread infiltration of soft tissues is rare From

this description of the pathologic anatomy<sup>2</sup> one can understand the formation of the roentgenologic findings of expansion and multiloculated areas of rarefaction or destruction of the bone, dense trabeculation and occasionally irregular calcified masses in the soft tissue tumor

It must be admitted that these roentgenologic findings are not pathognomonic of chordoma in the sacrococcygeal region. In fact, such findings elsewhere in the skeleton may indicate giant-cell tumor, osteochondroma, or myxochondroma, but the clinical picture and particularly the sacrococcygeal location of the lesion should suggest the diagnosis of chordoma. Giant-cell tumor and chondroma occur in younger individuals and their occurrence in the sacrococcygeal region is extremely rare. However, biopsy should always be relied upon to obtain the final diagnosis. It should also be mentioned that the roentgenologic findings for sacrococcygeal chordoma as described above are not present in case the tumor is mainly of ante-sacral or post-sacral origin without infiltration into the sacrum. When the sacrum is involved in such a case, the findings in the bone are likely to be those of pressure and secondary changes, as in the case of a very large chordoma reported by Willis (19), which apparently arose from the anterior surface of the sacrum and extended down into the upper part of the thigh and yet showed no marked involvement of the sacrum.

#### SUMMARY

1 The literature on the roentgenologic diagnosis of chordoma, especially in the sacrococcygeal region, was reviewed

2 Three cases of sacrococcygeal chor-

doma, with roentgenologic examination, were reported

3 Three cases and those reported by others were studied from the roentgenologic standpoint. Certain findings found in the three cases of our series and in many of the others are described, they are considered as characteristic of chordoma in the sacrococcygeal region

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<sup>2</sup> An abstract from Hass' article (6)

# EDITORIAL

LEON J MENVILLE, M D, *Editor*

HOWARD P DOUB, M D, *Associate Editor*

## RADIATION DOSAGE

Often in medical meetings, especially when cases are presented before a general gathering of men who are not radiation therapists, such a statement as the following is heard "This case had a test of radiation therapy" The remark, as it stands, is worthless, yet any attempts to persuade the speaker to give definite data as to the amount of radiation used are apt to elicit either a vague answer or a definite admission of ignorance on the subject

Why should we tolerate vagueness in regard to radiation dosages? Certainly we do not suffer it in reports on drug dosages It is almost impossible to imagine that a physician, in reporting a heart case in which digitalis had been administered, would fail to state the exact amount of the drug used It is still harder to imagine that his audience would let the omission slip by without remark

Even after the amount of radiation has been stated, the story is but half told, as a radiologist knows The technic of administration must also be known if we are to get a worthwhile picture of the case Negligence on this point would be held an egregious error in a report on the use of digitalis in a heart case Why is it not so regarded in radiation therapy?

To report radiation treatment and omit the dose is a waste of time—not only the time of the audience or readers, as the case may be—but of the many scientists, past and present, who have spent their time and energy in working out measurements for radiation dosages, not to mention the physician who prescribed the treatment

Another unfortunate tendency of speakers unversed in radiation therapy is to use loosely the terms "radiosensitive" and "radioresistant" To be of any use at all, these terms must be modified To say that a cancer is radiosensitive is as valueless, *per se*, as to say that it is large If the latter adjective were used, the immediate question would be, "How large?" The question, "How radiosensitive?" is an equally justifiable and necessary response, in view of the fact that recent results have

demonstrated "radiosensitive" and "radioresistant" to be purely relative words

A careless disregard of knowledge which has been painstakingly—and often painfully—gained is almost as great a misdemeanor as the oldtime custom of persecuting any one who advanced an original idea in science In a way, it is worse, because it is more insidiously destructive It is often the case that a technical term, as used by laymen, comes to have such broadness and indefiniteness of meaning that the technician or professional man himself subsequently discovers the necessity for redefining the term each time he uses it in order to bring it back to its true, well-limited sense

JOHN T MURPHY, M D

## COMMUNICATIONS

May 28, 1936

DR LEON J MENVILLE, *Editor*

RADIOLOGY

1201 Maison Blanche Bldg

New Orleans, La

"To the Editor

"The increasing interest shown in roentgen-kymography makes it necessary now at the outset that basic facts regarding this method be clearly established For this reason and others, I am moved to comment on certain sins of commission and omission in the article published by Scott and Moore in the May issue of RADIOLOGY

"The article states 'Hirsch reported on the requirements of a proper kymograph but did not describe its construction' It cannot be that, having read with great assiduity and assimilated thoroughly the article in the British Journal of Radiology, so generously referred to, they have ignored or forgotten the two contributions published in RADIOLOGY

"The paper of Hirsch in the April, 1934, RADIOLOGY, Vol 22, represents the first discussion of the construction, operation, and application of modern kymography published in this country In this article, on page 405,

Hirsch states, speaking of the kymograph, 'The arrangement is essentially a grid diaphragm mechanism with the springs removed. In place of the grid there is mounted a carriage to hold a  $14 \times 17$  cassette. This is mounted vertically, so that when released, the film falls by its own weight. On the front of the frame, between patient and film, there is mounted a lead grid consisting of slits 0.4 mm wide, spaced at a distance of 12 mm from each other. The grid diaphragm contactors have been so rebuilt that the exposure can be adjusted by means of a speed control. A time marker record, in fifths of a second, is impressed on the film during its exposure.' There then follows a description of the use of the time marker.

"A careful study of Scott and Moore's paper fails to reveal anything novel either in the construction or application of the kymogram. The use of the Bucky mechanism for the foundation of the apparatus is certainly not new and the description of the apparatus by Hirsch is as detailed as that given by Scott and Moore.

"It is true that Hirsch's article contains no picture of the Potter-Bucky diaphragm apparatus, which serves only as the mechanism for moving the grid. It is certainly true (see preface 'The Principles and Practice of Roentgen Therapy,' by Hirsch, 1925), as the Chinese say, a picture is better than a thousand words, but why clutter up our Journal with useless pictures or, for that matter, useless words?

"Further, even for two years before the publication of this first article, we have shown to those to whom our work was exhibited before its publication, and in numerous instances since, by word and letter, details of the construction of our apparatus indicating the simple way of modifying the Potter-Bucky diaphragm to make the kymograph.

"Dr. Scott and Dr. Moore accept the 0.4 mm grid and 12 mm spacing in naïve simplicity as if it were obtained as a gift from God. If they will take the trouble to study Table I (page 405) of the article above referred to, they will find that 0.4 mm slit, 12 mm spacing, and one second exposure was first used by us, yet in their article no credit is given for this, although it is a contribution of no little importance. The determination of the optimum slit width and spacing represents considerable preliminary work and much thought and experiment.

"They apparently do not appreciate that the most important part of the apparatus is

not the mechanism of the Potter-Bucky diaphragm outfit by which the film or grid is made to move, but the slit width and its spacing. It is this which, giving a wave form of considerable extension, rich in detail and superior to any wave form previously inscribed by any other arrangement, permitted us to analyze and discuss the significance of the serrations associated with valve closure and heart sounds (*Acta Radiologica*, Vol. XV, Fasc. 2, No. 84).

"Scott and Moore, in their listing of the requirements for an ideal kymograph, have written what amounts to an excellent summary of material published by Hirsch. All the requirements except three are included in Hirsch's listing in the *British Journal of Radiology*, Vol. VII, December, 1934. Of the three exceptions, one (No. 3) must be objected to on grounds discussed in the next paragraph, one (No. 8) represents an experiment which has been discarded by us years ago as unimportant, and one (No. 11) is only of partial value, since the more important source of motion is the breathing of the subject, and an immobilization band can scarcely be intended to inhibit respiration.

"Scott and Moore's suggestion embodied in point No. 3 is of questionable value. For very fast motions it is, of course, possible to diminish the size of the slit spacing and still preserve the record of complete cycles. But is there any value in making records of points closer together than 12 mm? On the other hand, in the gastro-intestinal tract, for example, the conditions necessary for recording a full cycle may justify the use (with the 0.4 mm slit) of greater slit spacings. However, does the difference between 12 and 18 mm length of record justify the added complication? Is not a spacing 18 mm getting dangerously large, since important lesions of the tract may themselves have an extent no larger than this?

"Further, the use of the multiple slit method was not first advanced by Stumpf, but by an American, Sam Katzman ('The Roentgen-ray Cardiograph,' *RADIOLOGY*, 1930, 8, 134-140), which device, though published then, had actually been completed and utilized some years previously. The numerous spaced slits were embodied in the apparatus he described, though the manner of movement of the film was different from that used in the present-day apparatus.

"Finally a word as to the kymoscope. This has not been stressed by Hirsch anywhere in

his writings because it is unimportant and of no value in advancing the application of roentgen kymography. True, it is always warranted to 'épater le bourgeois,' and mildly amuse the uninitiated, but why waste time with this plaything when the wave cries out for analysis? There are many secrets awaiting disclosure in the kymographic wave, why not concentrate on its study?

"Cinematizing the kymoscopic illusion gives, at best, only a faked movie. Surely, if it is desired to demonstrate the movements of the thoracic viscera—lungs, heart, diaphragm—the present, entirely feasible method of cinematizing the fluoroscopic image, according to the method of Reynolds, is far more preferable, desirable, and accurate."

Yours truly,

MYRON SCHWARZSCHILD

Dept of Radiology  
New York University  
School of Medicine

June 18, 1936

DR LEON J. MENVILLE  
Editor of RADIOLOGY  
1201 Maison Blanche Building  
New Orleans, La

"My dear Dr. Menville

'We thank you very much for the opportunity which you afforded us to read Dr. Schwarzschild's letter of May 28 and for giving us the opportunity to reply to it.

'One of us (S. M.) has enjoyed the friendship of Dr. I. Seth Hirsch for many years and holds his scientific achievements in highest regard. Because of this, anything which even remotely suggests that due appreciation of his contributions to roentgen kymography has not been given is particularly regrettable.

'The sole purpose of the paper, 'The Construction of Roentgen Kymographs and Kymoscopes,' was to present our experiences in the design and use of the roentgen kymograph and kymoscope in order to popularize what we believe to be an invaluable aid in the study of many pathological conditions. We advanced no claims to originality or innovations in the development of either the kymograph or the kymoscope. To read anything else into our paper is to introduce something entirely foreign to our intention. Under no circumstances do we wish to omit, detract from, or discredit any of Hirsch's work on kymography. It should be well known to all interested in the subject that

Hirsch introduced the modern kymograph (Stumpf's) to the medical profession of this country. We acknowledge and assume full responsibility for our failure to refer to Hirsch's articles published in RADIOLOGY, Vol. 22, No. 4, pp. 403-422, April, 1934, and Vol. 23, No. 6, pp. 720-737, December, 1934, reprints of which he kindly gave us. We also fully acknowledge "assiduous assimilation" of Hirsch's article, "The Examination of the Heart by the Roentgenkymographic Method," British Journal of Radiology, New Series, 1934, Vol. 7, pp. 728-754. Our exhibit at the Twenty-first Annual Meeting of the Radiological Society of North America fully credited Hirsch and carried the above references.

"We are not convinced that Hirsch's description of the construction of the kymograph is as detailed as ours. In our opinion, the description which we gave of the requirements for a suitable kymograph is more detailed than Hirsch's and more clearly presented than his summary in the British Journal of Radiology. We made reference to and acknowledgment of this article.

"The 12 mm grid spacing has been the standard used by Stumpf since 1931. ('Das Röntgenographische Bewegungsbild und Seine Anwendung,' Fortschritte auf dem Gebiete der Röntgenstrahlen (Ergänzungsband), 1931, 41, 15). However, the slit width used by Stumpf was 0.5 mm as compared with 0.4 mm advocated by Hirsch. As stated in our article, our first grid was 0.4 mm wide. We believe that a slight variation in the width of the slits is of theoretical rather than practical import. The superior detail of the waves shown by Hirsch and associate is to be explained by his exposure time of one second rather than by the width of the slit. We acknowledge this fact as an advance in the subject. The German kymographs commercially available in 1931 had an adjustable exposure timer varying from one to 60 seconds. A set standard for the exposure time for all individuals is impractical. The exposure time should be varied with the heart rate. With a grid spacing of either 0.4 mm or 0.5 mm, the increase in detail will be due principally to a short exposure which permits one cardiac cycle to be recorded on a single frame of the kymogram.

"We agree with Dr. Schwarzschild that the Potter-Bucky mechanism for moving the film is not the essence of a good kymograph but only a means of producing a uniform speed of

motion This is essential for avoiding distortion of the waves The desirability of using interchangeable grids of 6, 12, and 18 mm is purely a matter of personal opinion and experience We have found that the 18 mm grid is superior to the 12 mm grid for recording the relatively slow movements of the thorax and its contents during respiration The 6 mm grid has proved to be of value in studying the movements of various joints and in recording the rapid movements of deglutition It is possible that the 18 mm grid may not be the ideal one for gastro-intestinal use, but this can be determined only by further work

"We do not agree that a device for making a time record on the kymogram is unimportant (as stated by Dr Schwarzschild in paragraph 9), because in cardiac kymography we vary the exposure according to the pulse rate and consequently more frequently record a single cardiac cycle in a frame than would be the case if the timer were omitted With the time record inscribed on the film, the pulse rate can be accurately read from it as can the duration of various other movements

"The literature has been read again and it confirms our belief that Stumpf has priority in the use of the multiple slit grid for kymography He presented his work at the Second International Radiological Congress in Stockholm in July, 1928 ('Die Gestaltänderung des schlagenden Herzens im Röntgenbild,' *Fortschritte auf dem Gebiete der Röntgenstrahlen*, December, 1928, 38, 1055-1067) However, Sam Katzman (A I E E, Student Member), described his kymograph in August, 1928 ('The Roentgen-ray Cardiograph,' *RADIOLOGY*, August, 1928, Vol 11, pp 134-140) Comparison of the illustrations of these two authors shows that Stumpf's apparatus is considerably more advanced than Katzman's Because of this, and Stumpf's subsequent elaboration of the apparatus, we feel that undoubtedly he should be given credit for the development of the modern multiple slit kymograph It is a curious fact that Dr Schwarzschild did not mention Katzman in any of his articles except to list him in the bibliography which was alphabetically arranged, and yet he urges Katzman's priority now

"As to the kymoscope, we need only repeat our previous statement that the kymoscope is not necessary for the interpretation of the kymogram In fact, the kymogram can be far more profitably used by measuring the ampli-

tude and studying the other characteristics of the waves At the present time it is superficial to dismiss the kymoscope as a pretty toy with which to confuse the uninformed Its utility in the classroom is so obvious that comment should not be required A word as to the relative value of cinematizing the kymoscopic image and that of the fluoroscopic screen to claim superiority for the latter is to overlook the fact that the screen represents the mean value of the incident energy, on the one hand, and the mean value of the fluorescence, on the other Indeed, it seems to the writers that the kymogram itself indisputably establishes the fact that the fluoroscopic is the illusive and the kymoscopic image the true reproduction of that which actually takes place

"We are concerned chiefly in this communication with accuracy in reference to the work of others Therefore attention may be called to the following Dr Hirsch, in his brief historical sketch on kymography (*RADIOLOGY*, April, 1934, 22, 404), dates Sabat's original work as appearing in 1913 It actually appeared in 1911, and it was republished in 1913, because Gött and Rosenthal did not acknowledge this reference (Sabat, B, *Polnischen med Wchnschr*, 'Lwowski Tygodnik lekarski' Nr 28, July, 1911 Republished in *Fortschritte auf dem Gebiete der Röntgenstrahlen*, 1913, 20, pp 42-44) Likewise, Gott and Rosenthal are quoted by Hirsch as presenting their work in 1913 although their paper appeared in September, 1912 (Gott, Theodor, and Rosenthal, Joseph, *Münchener medizinischen Wochenschrift*, Vol 59, pp 2033-2035, September, 1912) Knox, in his address before the Royal Society of Medicine, described his work on kymography in October, 1922 (Knox, Robert, 'Cardiac Diagnosis A Survey of the Development of Physical Methods,' President's Address, Royal Society of Medicine Proceedings, 16, Parts 1 and 2, 1922-23, Section on Electrotherapeutics pp 1-30) Dr Hirsch dates his work in 1929 Stumpf's first report on kymography appeared in 1928 ('Die Gestaltänderung des schlagenden Herzens im Röntgenbild,' *Fortschritte auf dem Gebiete der Röntgenstrahlen*, 1928, 38, 1055-1067) Hirsch gives the date as 1929

"We commend Dr Schwarzschild for his keen interest in bibliographical accuracy and have made our own contribution to this end above. Some measure of the difficulty encountered in accurate reference can be gained

from the following Dr Schwarzschild, in his third from the last paragraph, refers to the article by Sam Katzman, 'RADIOLOGY, 1930, 8, 134-140' The correct reference is Katzman, Sam, The Roentgen-ray Cardiograph, RADIOLOGY, Vol 11, pp 134-140, published August, 1928 "

Very truly yours,

WENDELL G SCOTT, M D

SHERWOOD MOORE, M D

## CONNECTICUT STATE MEDICAL SOCIETY

### SECTION ON RADIOLOGY

The Connecticut State Medical Society held its one hundred and forty-fourth annual meeting at Hartford, May 20-21

The program of the Section on Radiology was as follows

"Results of Comparative Doses on Human Tumors Using Fever and Roentgen Radiation" (illustrated), by Stafford L Warren, M D, Associate Professor of Radiology, University of Rochester, N Y (*by invitation*)

Discussion opened by William S Stone, M D, Westport, and George T Pack, M D, New York City (*by invitation*)

"Roentgenologic Study of the Appendix" (illustrated) by Hugh Wilson, M D, Assistant Professor of Radiology, Yale University School of Medicine, New Haven (*by invitation*)

Discussion opened by Ralph T Ogden, M D, Hartford

At the business meeting which followed the program the following officers were elected for the coming term R H Lockhart, M D, Bridgeport, *Chairman*, Max Climan, M D, Hartford, *Secretary-Treasurer*

## THE X-RAY IN INDUSTRY

A new chemical and metallurgical testing and production control laboratory which is one of the most modern industrial laboratories in the United States has been placed in service at a large manufacturing plant The laboratory is another unit of the company's expansion and modernization program

Completely air-conditioned and furnished with new x-ray, physical testing, and chemical analysis equipment, the laboratory is now working on a 24-hour-day basis It is used to analyze the molecular structure of steels, to determine the physical properties of metals

and fabricated parts, and to analyze steels, irons, and other metals, textiles, paints, oils, and rubbers used in the factory

Included in the equipment is a new x-ray machine having an oil-cooled fine focus radiographic tube of 230,000-volt capacity It has sufficient intensity to penetrate four inches of steel, and through its use flaws less than 2 per cent of total thickness are detected Its intensity permits a great time-saving in making x-ray photographs—a crankshaft, for example, being photographed in about three minutes To protect the operators from the rays of the machine, it is housed in a lead-walled room, and the operator watches the machine in operation through a safety lead glass

The x-ray department also includes a diffraction machine equipped with a new tube which will obtain in 20 minutes films which formerly required from 24 to 70 hours of exposure The machines are used largely in research to improve casting and steel-treating technique through a study of the atomic structure of the finished steels and alloys

Another new instrument in the laboratories is the profilograph, the third one of its kind to be constructed, designed at the University of Michigan It is used to examine steel finishes Through an optical magnifying system, any imperfections in the finish which are detected by a diamond point are magnified 2,000 times vertically and 64 times horizontally Thus the graph of a surface of a one-eighth inch specimen of steel becomes a readable chart eight inches long, with minute irregularities showing as deep ridges

Well-equipped developing and printing rooms adjoin the x-ray and metallographic rooms In these rooms also are miniature molding presses used to mount the metal specimen in bakelite for easy handling The microscope used in the metallographic studies magnifies over 1,000 diameters, revealing the structure of a cross-section of steel

In the physical testing rooms, various parts of machinery are subjected to heavy blows, twisting tests, and compression tests to determine their resistance and strength In this department, two new hydraulic machines have been added to the equipment, one, a 100,000-pound machine, and the other a light weight machine permitting greater accuracy in testing light parts, such as fabricated gears

In the analytical laboratory, all work tables are of stainless nickel-chrome-steel, and fur-



naces and other apparatus are of the latest improved type. At the end of the room is a specially constructed salt spray cell, where plated parts are subjected to salt baths. The laboratory throughout is lighted by an improved "daylight" system with batteries of five special bulbs providing a light as nearly equivalent to daylight as illumination engineers have been able to devise.

The laboratory is manned by a staff of 65 technicians, working in shifts. Since an analysis is made of every cast of metal from the blast furnaces, some part of the staff is on duty twenty-four hours a day, keeping an accurate check on the materials used in the factory.

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## BOOK REVIEW

**RADIUMDOSIMETRIE VERFAHREN UND BISHERIGE ERGEBNISSE** By DR. KARL G. ZIMMER. Monograph, Fortschritt d. Geb. d. Röntgenstrahlen, 1936, Vol. 49, 40 pages, 33 illustrations. Published by Georg Thieme, Rossplatz 12, Leipzig C 1, Germany. Price RM 6.50.

This monograph is an admirable compilation of recent advances in physics in the measurement of gamma rays. The discussion is quite technical and perhaps more intelligible to physicists than to physicians, however, Dr. Zimmer makes a point of mentioning the types of measuring instruments which are less complicated and may be used profitably by the practicing physician.

The subject of radium dosimetry is divided into two large fields: (1) relative dosimetry, including the spatial distribution of radiation in the neighborhood of radium preparations and the best arrangements of single sources of applicators, and (2) absolute dosimetry which

deals with the selection of a unit of radium dosage and its practicability.

In regard to relative dosimetry the author describes the recent instruments in this field with special reference to the Radium-Hammer dosimeter of Pychlau. Other recently developed instruments are also discussed. The photographic method of measurement of Holthausen and Hamann is reviewed, and this is followed by an analysis of biological methods such as the use of *Drosophila* eggs. The mathematical method of calculation is then portrayed with tables calculating the dosage delivered from needles or tubes, and a diagram showing the intensity of irradiation from plaques. Finally, relative dosimetry is concluded with a comparative discussion of the above-mentioned methods.

In regard to absolute dosimetry, the author states that the question of a suitable unit of gamma-ray dosage can be taken as settled since the majority of authors accept the roentgen (r) unit. He discusses the difficulties of measurement of gamma rays with a large chamber and the advantages of the air-walled small chamber. He maintains that for practical measurement in r units, the important points are adequate wall thickness of the chamber, and for measurements in scattering media, wave length independence of the chamber.

A section is devoted to special problems of dosage with radium bombs and measurements of dosage are quoted. There is discussion regarding the measures necessary for protection of radium workers.

The author points out that very little work has been done to date regarding dosage with alpha and beta rays, although beta rays possess considerable importance in treatment.

The work is well illustrated with tables and charts showing the best arrangement of radium applicators for equal distribution of irradiation. There are several excellent tables and charts showing depth dosage with various filters and applicators. A very good bibliography is appended.

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## LUNGS

The Lower Lung Line Ephraim Korol *Am Jour Roentgenol and Rad Ther*, December, 1935 34, 740-743

In films of the upper abdomen there may be seen a horizontal line running from the lateral chest wall toward the first lumbar vertebra on each side. This line, referred to as the lower lung line, represents the lower posterior pleural boundary, i.e., the fold of parietal pleura reflected from the posterior chest wall onto the diaphragm. This line may be followed into its junction with the line representing the posterior mediastinal pleural fold.

Occasionally the lower anterior pleural fold may also appear as a horizontal line at a slightly higher level than the posterior lung line. The anterior line has been seen only in cases of emphysema; it can be traced on the film into the pericardio-pleural fold.

In cases of emphysema and visceroptosis, also in cases of pneumothorax, the lower lung lines often appear in the chest roentgenograms as horizontal lines crossing the twelfth rib a short distance below the dome of the diaphragm which is flattened and placed low in these cases, and may be mistaken for pleural fluid.

In cases of atelectasis or fibrosis of one lobe with compensatory emphysema of the healthy lobes, the lower lung line often shows on the routine chest roentgenogram due to ballooning of the pleural fold by the emphysematous lung.

S M ATKINS, M D

## PEPTIC ULCER

The Importance of the Anteroposterior Film of the Duodenal Bulb for the Exact Localization of Duodenal Ulcer B A Fanardjian *Röntgenpraxis*, December 1935 7, 806-813

It is of considerable importance to localize a duodenal ulcer, especially for the surgeon. The roentgenologic demonstration of a niche is not always possible on oblique views due to anatomical variations. It is possible, according to the author, to predict the exact situation (anterior or posterior wall) on the anteroposterior film. The rules applicable for this relationship are as follows: (1) If there is a defect on the lateral contour of the cap on the anteroposterior film, the niche can be shown on the anterior wall, (2) if the defect is seen on the medial contour of the cap on the anteroposterior view, the niche can be demonstrated on the posterior wall, and (3) if the defect is seen on the medial as well as on the lateral contour of the cap on the anteroposterior view, the niche can be demonstrated on the anterior as well as on the posterior wall ("kissing ulcers").

This relationship is almost a law and has, heretofore, not been used enough by the radiologist. The author has proven his contention in several hundred ulcer patients. Only in complicated cases might there be deviations from the above rules.

HANS W HEFKE M D

## PNEUMOTHORAX

Indications for Collapse Therapy A Heymer *München med Wchnschr*, Jan 17, 1936, 83, 101-105

Artificial pneumothorax is effective in pulmonary tuberculosis, by mechanically resting the affected lung, producing passive congestion and lymph stasis, causing retraction and collapse of cavities, and diminishing the absorption of toxic products. The most important consideration is the type rather than degree of involvement, thus, a purely exudative lesion, even though of relatively small extent, is actually made worse by collapse therapy. This is due to the non-compressibility of the diseased area owing to the exudate, and the causation of overwork of the normal pulmonary structure to compensate the diminished space, which, in turn, produces a marked exacerbation of general symptoms, by increased absorption of expressed toxic material. If there is no reasonable outlook or definable evidence of resisting contiguous pulmonary tissue, then collapse therapy should not be employed. It is patent that the most favorable cases are those of the fibrotic and fibro-ulcerative type, with or without cavitation. A diagnosis of the pure exudative type can be made only by correlation of clinical symptoms and signs of activity with roentgenologic evidence and hematologic study.

It is imperative to establish the presence or absence of tubercle bacilli, by assiduously examining the sputum, by culture, smear, and guinea pig inoculation, also examination of gastric contents and laryngeal smear. Repeated negative findings indicate conservative treatment as being adequate. One exception is the presence of pulmonary tuberculosis of a mother with children as potential contacts, for in such a circumstance, collapse therapy is strongly urged.

It has been found that the prognosis is far better in the lower social strata, i.e., factory workers, in whom collapse therapy has been instituted, together with added benefit of rest and good nourishment. One great advantage of collapse therapy is that it is not an irreversible procedure, as are other operative procedures. Other contra-indications to collapse therapy are bronchial asthma, marked pulmonary emphysema, and cardiac weakness only when decompensation is present. No age limit has been found. Pregnancy and diabetes controllable by insulin are not contra-indications. If other organs are involved the decision rests upon the severity of involvement of the former. Thus laryngeal tuberculosis is generally benefited. Unilateral renal tuberculosis is a strong indication, whereas bilateral involvement contra-indicates radical collapse therapy. It should be remembered that tubercle bacilli can be filtered through a normal kidney, and their presence do not necessarily mean parenchymal involvement. Extensive bilateral pulmonary tuberculosis producing dyspnea is an apparent contra-indication for artificial pneumothorax. Other surgical methods such as thoracoplasty, plombage and phrenico-exeresis should be employed when artificial pneumothorax is mechanically not feasible, i.e., pleural adhesions, markedly thickened pleura and the like.

WILLIAM R STECHER, M D

Spontaneous Pneumothorax E Schott München med Wehnschr, Nov 1 1935, 82, 1751-1756

The pathogenesis is briefly considered, and although the author favors the theory of ruptured emphysematous blebs or hülke, nonetheless none of these could be roentgenographically demonstrated after reinflation of the lung. The possibility of tuberculosis or so-called "congenitally weak pleura" is considered as etiologic factors. In practically all cases observed there was a concomitant pleural effusion, and its presence is considered as favorable to healing of ruptured pleura. The differential diagnosis must be made between true pulmonary abscess and encapsulated hydropneumothorax, a distinction which is readily accomplished roentgenographically.

Injection of dextrose solution into the pleural cavity aided the healing and reinflation of the collapsed lung

WILLIAM R. STECHER M D

## RADIATION, PHYSICS OF

Registration of the Ionization Curve of a Single Alpha Particle H Alfvén Ztschr f Physik Nov 25, 1935, 97, 718-724 (Reprinted by permission from Science Abstracts, Sect A, Physics, Jan 25, 1936, 39, 35)

The track of ions which is produced by an alpha particle moves in a homogeneous electric field with constant velocity. The whole ionic track can thus be brought progressively into a discharge chamber, where it produces a current which gives the ionization curve. The current which is of the order of magnitude  $10^{-12}$  A is by a specially constructed amplifier so much amplified that it can be oscillographed. The oscillograms thus obtained give a good picture of the ionization curve. The method can perhaps be useful in the study of nuclear reactions J J S

Deflection of Alpha Particles R Mercier and P Scherrer Helv Phys Acta, 1935 8, 589-590 (Reprinted by permission from Science Abstracts, Sect A, Physics, Jan 25 1936, 39, 35)

A brief description of apparatus for demonstrating the deflection of alpha particles by nuclei W E P

Radiotherapy (Roentgen Rays, Radium) Arthur U Desjardins Jour Am Med Assn Dec 21 1935, 105, 2064, Dec 28 1935 105, 2153

When cells of a given kind are exposed to a certain dose of radiation some are destroyed, some are injured but regenerate later and some do not show any deleterious effect. Such variation in the susceptibility of different cells of the same kind is probably due to the metabolic stage of the cells and perhaps to other unknown factors.

Whatever the main reason for variation in the radiosensitiveness of different cells of the same variety may be this does not affect the fundamental law of the specific sensitiveness of different varieties of cells a law based on innumerable experiments on animals and substantiated by extensive clinical observations.

Biologic considerations are discussed under a classification in the order of their degree of sensitiveness.

Under clinical radiotherapy the practical aspects of radium and roentgen rays are discussed as they apply to inflammatory diseases and tumors. Methods of application and also radiation sickness are included in the discussion.

CHARLES G SUTHERLAND M B (Tor)

## RADIUM

Recent Advances in Radium Therapy H S Souttar British Med Jour Feb 29 1936 No 3,921 401-404

While it has been observed that as a general rule the cells of malignant tumors are destroyed more readily by radium therapy than normal cells, it is doubtful that this action is due to the individual sensitivity of the tumor cell but rather to biological characteristics of the tumor cell which render it more sensitive than the cells of most adult tissues. Malignant tumors grow more rapidly than normal tissues, therefore, the individual cells are constantly undergoing nuclear division and their chromatin is more vulnerable to radium therapy. Another factor which plays a part is that malignant tumor tissue is more embryonic and less highly developed than normal tissue.

The changes in connective tissue as a result of radium therapy is somewhat different from the effect of radium on cellular elements. These changes result from a slowly developed endarteritis accompanied by changes in the capillaries, affecting their permeability and the nutrition of the tissues they supply. Thus it is known that radium injures both the tumor cells and the tissue cells and the efficiency of radium therapy depends upon obtaining the maximum effect on the tumor cells with the minimum effect on connective tissue.

The ideal desired in this form of therapy is the thorough and uniform irradiation of the entire field. This should include all lymphatic areas probably involved as well as the primary field. Uniformity in irradiation therapy is obtained by the use of proper filtration to eliminate the softer rays.

It is necessary that the unit of radiation be accurately defined. While the r is considered the most ideal unit as it allows comparisons between x rays and radium the practical difficulties of measuring r are great. It has therefore been suggested that the "natural radium unit" be adopted. This unit is the amount of radiation delivered at a distance of one centimeter by one milligram of radium. However, this does not consider the effect of filtration. The author has suggested an appendix from which the dosage may be determined with due consideration to filtration.

The insertion of radium needles into the tissues is considered one of the most useful methods of application. Such needles provide constant sources of radiation of known value. The wall of the needle should not be less than 0.5 mm of platinum in order that effective filtration may be obtained. The needles should be placed at the growing edge of the tumor and in such a manner that cross fire may be obtained.

Radon seeds are small tubes of platinum or gold in which are sealed up minute amounts of radium emanation. At first the effect is the same as with radium needles but as time passes the emanation decays so that at the end of a two weeks' period the action is negligible. The author has devised an introducer for the application of radon seeds which allows rapid introduction of these elements.

Another method of application of radium is the use of plaques and molds. This has the advantage of more uniform irradiation by increasing the distance from the surface. The arrangement of the radium on the plaques is determined by placing one half of the radium on the surface of the plaque and the other half around the margins of the plaque. The amount of radium needed to give the required intensity at the surface may be determined by the author's instrument.

With larger amounts of radium beam radiation is employed. Considerable research is going on at present with various forms of applicators, and the author has devised several units which allow the delivery of radium to the unit by pneumatic means after placing the unit in position. This eliminates the usual cumbersome heavy unit without endangering the patient or attendants. A short beam unit which makes use of smaller amounts of radium, and which because of its smaller size has a greater field of usefulness has been devised by the author.

— J. N. ANÉ, M.D.

Radium Dosage and Technique in Carcinoma of the Skin, with Special Reference to Interstitial Irradiation with Platinum Iridium Needles. H. N. Cole and J. R. Driver. *Am Jour Roentgenol and Rad Ther* May 1935, 33, 682-689.

Prolonged interstitial irradiation with heavily filtered platinum iridium radium needles of small intensities is superior to other forms of therapy in the treatment of selected cases of skin malignancy. The authors use needles containing 1, 2 or 3 mg. of radium element and 27-44 and 60 mm. in length. The radium is in cells 15 mm. in length containing 1 mg. each of radium.

In small tumors, the needles are arranged parallel and in large tumors radially. They are inserted through the normal skin and through or under the tumor under aseptic conditions and local anesthesia. The calculation of the dose is simple, for the needles are so constructed that they will destroy 1 c.c. of squamous-cell carcinoma per running centimeter of active radiating focus in seven days. Hence needles are placed 1 cm. apart and each cubic centimeter of tissue will receive 116 mg. hr. in seven days or 160 mg. hr. if left 10 days. A biopsy is taken before or at the time treatment is instituted.

At the end of about one week the overlying skin becomes deep red or purple and on the tenth day vesiculation may be present to be followed by exfoliation of the epidermis exposing an adherent yellowish fibrous exudate. Healing requires from three to six weeks. The resulting scar after a few weeks is healthy and there is little or no deformity.

The indications for this type of treatment are rapidly growing or advanced prickle-cell carcinoma, extensive basal or baso-squamous carcinoma, deeply growing types or types with scar tissue, malignancies over bony prominences in which bone may be involved, areas having underlying cartilage or fascia or dense integument, and recurrences.

The result of treating metastases by this method supplemented by external irradiation has usually been good.

S. M. ATKINS, M.D.

Radium Dosage and Technique in Carcinoma of the Tongue. Frank E. Simpson. *Am Jour Roentgenol and Rad Ther*, July 1935, 34, 63-68.

Every carcinoma of the tongue unless it is too extensive or shows metastases, should have implantation therapy. If every part of the tumor can be reached a clinical cure often results.

The author employs lead antimony radon tubules which are left in place permanently and the dose is as large as the normal tissue can stand without serious injury. These are implanted by a syringe-like apparatus under local anesthesia. Biopsies are done by means of cutting forceps or scissors.

Treatment is not held up on account of month infections, which are not radically treated. Metastatic nodes are treated either by roentgen or radium bomb radiation.

S. M. ATKINS, M.D.

Radium in the Treatment of Metastatic Epidermoid Carcinoma of the Cervical Lymph Nodes. Douglas Quick. *Am Jour Roentgenol and Rad Ther*, May 1935, 33, 677-681.

All cases of upper mucous membrane tract cancer acceptable for treatment receive roentgen therapy to both sides of the neck to a degree that produces an intense erythema at the end of two or three weeks, to be followed by scaling. Necks presenting no palpable glands receive no further treatment.

When glands are palpable treatment varies. In the strictly anaplastic and in the extremely advanced metastatic involvements, especially in cases in which the primary growth is far advanced regardless of the histologic type, roentgen therapy alone is the rule.

Surgical dissection is limited to cases that show fully differentiated epidermoid carcinoma, palpable involvement unilateral, capsule of the nodes intact if the patient's general condition is good and in whom primary growth is controlled or gives signs of future control. The dissection, however, must be most radical.

In all other types, interstitial irradiation therapy is employed following the initial roentgen therapy. The author prefers radon seeds implanted in the nodes not through the skin but after exposure of them under local anesthesia. The dosage varies but should always be carried to the limit of normal tissue tolerance.

The minimum is 3,000 mc hr and maximum 10,000 mc -hr. Nodes over from 5 to 7 cm in diameter are the upper limit in size suitable for irradiation treatment. The recurrent node is not to be treated surgically even if the capsule is intact, but by implantation.

In fat necks, and in sites near the salivary glands, scar tissue and nerves, the dose must be watched with care. Repetition of interstitial irradiation is contra indicated. Syphilis has no bearing, but in the presence of infection in the neck or even in the mouth, this type of treatment is contra indicated.

S M ATKINS, M D

Complications and Injuries in Radium Therapy. Ira I Kaplan. *Am Jour Roentgenol and Rad Ther*, July, 1935, 34, 77-80.

Radium therapy requires training, experience, and attention to the essential physical and biologic factors associated with it. Injuries following radium therapy are traceable to failure in diagnosis, mistakes in judgment, errors in technique and in the after-care of the patient. Radium injuries are in many instances due primarily to faulty technique and are most often preventable.

S M ATKINS, M D

Mutations Produced in the Fruit Fly by Alpha Particles Following Inhaling of Emanation. K G Zimmer and N W Timoféeff Ressovsky. *Strahlentherapie*, 1936, 55, 77.

Male fruit flies were placed in a vessel containing radium emanation. It was possible to produce mutations; further studies showed that they were due to the effect of alpha particles.

ERNST A POHLE, M D, Ph D

Long Freedom from Symptoms in a Carcinoma of the Esophagus Treated with Radium. S Epstein. *Strahlentherapie*, 1936, 55, 127.

The author observed a case of carcinoma of the esophagus (proved by biopsy) which responded well to repeated applications of radium. Heavily filtered screens were placed in the esophagus with a flexible sound. The patient died from acute nephritis four and one-half years after the treatment. While no autopsy was obtained, clinical symptoms suggested that several weeks before death a beginning recurrence was present in the esophagus.

ERNST A POHLE, M D, Ph D

Epithelioma of the Ear Lobe. S Laborde and E Via. *Strahlentherapie*, 1936, 55, 114.

At the Cancer Institute of Paris the authors found that among 763 skin cancers seen since 1922 there were 59, or approximately 8 per cent epitheliomas of the ear lobe. In nine cases no treatment could be given, either because of the extent of the lesion or refusal of the patient to enter the hospital. In six cases the tumor was removed by the endotherm knife but the remaining cases were treated by radium. In small tumors par-

ticularly in the edge of the helix, radium needles containing 2 mg of radium and filtered through 0.5 mm Pt were inserted and left for from three to seven days. In other cases, surface applicators consisting of 2, 5, or 10 mg screens filtered through 1.5 mm Pt were used depending on the size and depth of the lesion. Extremely high doses are contra indicated since they not only fail to produce a cure but apparently render the condition worse because of necrosis of the cartilage complicated by secondary infection. With more conservative doses the results have been very satisfactory. Photographs of a series of cases before and after treatment are appended.

ERNST A POHLE, M D, Ph D

A New Method in the Preparation of Highly Concentrated Radium Emanation Tubes. O Werner. *Strahlentherapie*, 1936, 55, 185.

The author briefly describes an emanation apparatus which he developed over a period of years. It permits the preparation of highly concentrated emanation tubes with an efficiency rate of about 80 per cent. A schematic drawing of the apparatus is shown with the article.

ERNST A POHLE, M D, Ph D

Absorption Coefficients of Hard Gamma Rays. W Gentner. *Ztschr f techn Physik*, 1935, 16, 416-418. *Phys Ztschr*, Dec 1, 1935, 36, 810-812. (Reprinted by permission from Science Abstracts, Sect. A, Physics, Jan 25, 1936, 39, 35.)

Measurements were made of the change in the absorption coefficients for hard  $\gamma$  rays of different wave lengths in Pb and of the variation of the absorption coefficient for the hard  $\gamma$  ray,  $h\nu = 2.65$  MV, from  $\text{ThC}''$  with absorbers of different atomic number. In both cases good agreement was obtained with existing theory in terms of the three absorption processes involving the photo-electric effect, Compton effect and pair formation.

F C C

Cystic Tumor of the Left Cerebellar Hemisphere and of the Anterior Portion of the Vermis. Post-operative Recurrence—Efficacious Radium Therapy. Angelo S D'Emidio. *Archivio di Radiologia*, 1935, 11, No 3-4, pp 231-238.

Professor A Santoro D'Emidio reports the case of a child, aged 5, who had a recurring cerebellar tumor. A successful result was secured from radium therapy, an improvement which has lasted more than two years. In such cases he recommends light radium therapy repeated at short intervals.

E T LEDDY, M D

Radium Dosage and Technique in Carcinoma of the Tonsil, Pharynx and Larynx. Max Cutler. *Am Jour Roentgenol and Rad Ther*, May, 1935, 33, 690-693.

Treating five patients suffering from relatively radioresistant adult, squamous-cell carcinoma with

radium packs at a distance of from 10 to 15 cm according to the technic of Coutard, the author has proven that initial sterilization of squamous-cell carcinoma can be effected even though the total time is prolonged over periods varying from 30 to 60 days

S M ATKINS, M D

Half life Period of Radium E A Pompéi *Jour de Physique et le Radium*, November, 1935, 6, 471 472 (Reprinted by permission from Science Abstracts, Sect A, Physics, Jan 25, 1936, 39, 35)

The half life period of Ra E, determined by I Cuier and Chamié's compensation method, is  $5.02 \pm 0.01$  day

C A S

Radium Therapy of So-called Radioresistant Epithelioma W Schloss and H Smerekler *Strahlentherapie*, 1936, 55, 105

Epithelioma located in the nasolabial fold, dorsum of the nose, inner and outer corners of the eye, and the ear are assumed to be fairly radioresistant and difficult to treat. At the Municipal Radiation Institute in Vienna, 187 of these cases were seen during the period from 1931 to 1934. 173 were treated and 128 became free from symptoms. Among these were 23 cases which had been treated elsewhere or developed recurrences. The method of treatment consisted of the application of screened radium filtered through 1 mm Pt. For each case a carefully adapted mold was prepared and applied to the lesion at a distance of a few millimeters. A very small dose per hour was used, the total treatment extending over several days.

The distribution of the dose of radiant energy was determined by means of a Sievert condenser dosimeter, diagrams and tables giving the results of these measurements are shown in the article. One important point is the rapid drop of the intensity with the depth. At 15 mm below the skin only 18 per cent of the surface intensity was measured. The reactions were relatively mild, undoubtedly because of the protracted application of the dose.

ERNST A. POHLE, M D, Ph D

Pre-operative Radium Treatment of Rectal Carcinoma Harry H. Bowing and Robert E. Fricke *Am Jour Roentgenol and Rad Ther*, December, 1935 34, 766-769

The treatment of carcinoma of the rectum has proved to be a difficult problem for the surgeon and the radium therapist owing to the relative inaccessibility of the lesion, its usually advanced stage when first seen and the usual presence of distant metastatic involvement. In some cases, surgery alone, and in others radium treatment alone has resulted in cure.

In cases in which patients present themselves reasonably early, when cure seems possible, more aggressive radium treatment followed after three months or more by surgical excision of the carcinoma, seems the logical procedure.

A preliminary report is given on 58 patients selected for this plan of treatment in the years 1930 to 1933,

inclusive. Only 37 of them completed the course of treatment by undergoing radical excision of the growth after radium treatment. Thirty-one of the patients are living at the present time, although two are seriously ill and two others may have residual trouble. The remaining 27 patients appear to be well and free of recurrence. In five of these cases complete healing of the posterior wound has not yet occurred, six patients have been perfectly well for more than four years.

Careful microscopic examination of the removed tissue was carried out in all cases following surgical excision of the growth. In three cases no evidence of carcinoma whatsoever was found in the surgical specimen, radium treatment apparently having destroyed all vestiges of the growth. In three other cases the pathologist found that most of the malignant cells had been eradicated by radium.

S M ATKINS, M D

## ROENTGEN-RAY BURNS AND INJURIES

Contribution to Our Knowledge of Roentgen Injuries H. Aretz *Strahlentherapie*, 1936, 55, 633

The author studied the records of all cases of x-ray injuries observed during the last ten years at the Skin Clinic of the University of Bonn. His critical analyses of the causes for these injuries are of interest to all radiologists since in most instances brief clinical data and notes as to dosage are given. From the tables in which the results are compiled it appears that eight injuries occurred in the diagnostic and 44 in the therapeutic field. Twenty-seven of all patients were male and 25 female. The injuries following diagnostic procedures occurred after fluoroscopy of the stomach (5), localization of foreign bodies (2), and roentgenogram of the skeleton (1). The injuries observed in the therapeutic cases were distributed as follows: uterine fibroid (3), sterilization (1), ovarian tumor (1), carcinoma of breast (5), carcinoma of sigmoid (1), tuberculosis of the joint (2), spina ventosa (1), tuberculous gland (8), tuberculosis of the skin (1), lupus vulgaris (2), hypertrichosis (1), tinea (2), psoriasis (3), eczema (12), epidermodysplasia (1). One table lists all cases and gives the diagnosis and degree of injury, information as to whether it was primary, combination or late injury and its possible cause. It appeared that 22 cases were in all probability due to an error on the part of the physician, five were due to overdosage, three to some action on the part of the patient which aggravated the x-ray reaction, five to some additional factor (for instance, chemical irritant), 15 were unavoidable because of our limited knowledge available at the time of the exposure, one case could not be explained, and in one the original diagnosis of injury had to be changed.

As prophylactic measures the author mentions proper training of the radiologist, strict filter control, and the use of an integrating dosimeter. Injuries due to a combination of factors cannot always be avoided. However, no injury is excusable in diagnostic roentgenology.

ERNST A. POHLE, M D, Ph D



## ROENTGEN-RAY DOSAGE

The Biological Measurement of Depth Dosage with 165 kv and 650 kv Roentgen Rays P S Henshaw and D S Francis Am Jour Roentgenol and Rad Ther December, 1935, 34, 789-797

Depth intensity measurements in paraffin were made with 165 kv and 650 kv roentgen rays using wheat seedlings *Drosophila* eggs and an ionization chamber. It was found not only that the biological measurements were different from the ionization measurements made but that the biological measurements differed among themselves at different depths.

When the effect at the surface was taken as 100 per cent, in each case the ionization measurements at points below the surface were found to be above the biological measurements for both 165 kv and 650 kv.

These results therefore indicate the possible error which may be encountered in basing biological depth dosages on measurements made with an ionization chamber. Further, they show how biological responses to radiation may vary when exposed under different conditions.

S M ATKINS, M D

Our Changing Concepts Regarding the Skin Dose with Some Notes on the Production of Epidermolysis Walter L Mattiek Am Jour Roentgenol and Rad Ther, October, 1935 34, 491-496

The production of the epidermolytic reaction to radiation presupposes an almost complete destruction of the epidermal layers leaving a relatively intact dermis with vascular and connective tissue elements. This is followed in forty to fifty days after the beginning of treatment by complete restitution through regeneration of the basal layer of cells some of which have usually survived in islets about the hair follicles and near the edge of the irradiated area. At the State Institute for the Study of Malignant Diseases, Buffalo N Y it has been possible to produce typical examples of this reaction by a single dose of 3,000 r tissue-measured, or 2,000 r primary roentgen radiation at 23 r per minute rate and 0.11 Ångström lambda effective thus entirely eliminating both protraction and fractionation in its production. Similarly, with 0.16 Ångström lambda effective in a single dose of 1,850 r tissue measured or 1,280 r primary radiation at 65 r per minute a marked redness followed by severe vesiculation and accompanied by the usual epithelitis of the mucosa, was produced. The production of the necessary effective saturation or cumulative dose, in accordance with the effective wave length of the radiation used, is of paramount importance no matter to what limit these total dosage figures may be carried. Such total dosage figures are therefore, of little importance unless accompanied by factors of total time over which the treatments are carried daily dose in r, quality of the beam, etc. Epidermolysis similar to that of Coutard was accomplished with 200 kv, 0.5 mm of copper 65 r per minute and 50 cm skin target distance, developing 0.16 Ångström lambda effective by

the administration of 1,300 r skin effective saturation or 1,960 r tissue measured radiation in eight days. If alternate neck fields are used every other day for approximately twenty doses over three weeks it is necessary to go as high as from 3,000 to 3,500 r primary radiation on each field to build up to 1,300 r saturation effective. The daily tissue recovery coefficient is 0.06 plus for the 0.11 Ångström lambda effective wave band, and 0.08 for the 0.16 Ångström lambda effective wave band (the skin saturation effective of approximately 2,000 r is arrived at for the heavier filtration with 0.11 Ångström lambda effective and 1,300 r for the lighter 0.5 mm copper band primary radiation).

J E HABBE, M D

## ROENTGEN-RAY THERAPY

The Effect of Coil Fields in Short Wave Therapy. Temperature Measurements on Several Layers of Electrolytes in the High Frequency Coil Field J Pätzold and P Wenk Strahlentherapie 1936 55, 692

On the Continent short wave therapy is usually applied by placing the patient in a condenser field while in this country 'coils' have lately been advocated. The authors undertook, therefore a comparative study of these two methods of application. The experimental procedure is described in detail coils with one three and eight windings were used with wave lengths of 6 and 25 meters. The authors conclude that the 'coil' type of apparatus can be used for wave lengths below 10 meters, provided the output of the machine is sufficiently high.

ERNST A POMER, M D, Ph D

Further Discussion of the Saturation Method of Roentgen Therapy in Deep seated Malignant Disease George E Pfahler Am Jour Roentgenol and Rad Ther, November, 1935, 34, 629-636

The author emphasizes the similarity in principle of his 'saturation method' and the more recently developed Coutard therapy. He recognizes that some of the older charts constructed show saturation values too low (the curve being too high) although with these older values it has been possible to reach a mild erythema by building up the dosage on this curve and to retain the erythema throughout the later stages of the treatment.

In the application of the saturation method which requires the building up of 100 per cent of an erythema dose in the tumor tissue as soon as possible without producing radiation sickness or damage to the surrounding normal tissues both surface and depth doses must be carefully determined and in all possible instances cross firing methods must be used directing the rays by the side of rather than through essential organs.

Studies were made on mice with transplantable adenocarcinomas. Some of the animals were irradiated with single prolonged exposure others with simple divided protracted radiation and still others by the so-called 'saturation method'. Results showed that the

response of the tumor was less the longer the interval had been between the administration of partial doses, indicating that the influence of divided doses is the same with regard to malignant tumors as with regard to other living tissue, namely, that cumulation is incomplete. In spite of this incomplete cumulation, however, it is not impossible that the therapeutic effect may be better from divided doses than from a single full irradiation. The final conclusions from this experimental study were that in the transplanting of tumors in mice the treatment by protracted fractionated irradiation should be preferred to massive doses, but that the saturation method was definitely superior to simple dividing of the dose.

While one may successfully administer as much as from six to ten erythema doses over the tissues of the neck by the Coutard method (such a quantity of radiation being shown by experimental work of Martin Quimby and Pack to be necessary for the destruction of cancer tissue), the writer warns against administering more than a total of three or four erythema doses over the abdomen on any one portal because of the great danger of fat necrosis. The same warning would apply to radiation over the lungs, heart, intestines, liver, or the spleen. A saturation curve for 200 kv, 0.5 mm copper plus 2 mm aluminum, and tables of equal erythema reactions following different percentages of erythema doses administered daily are included.

J E HABBE, M D

Neoplasms of the Oral and Upper Respiratory Tracts Treated by Protracted Roentgen Therapy. William Harris. *Am Jour Roentgenol and Rad Ther*, October, 1935, 34, 482-490.

The writer reiterates the principles of Coutard's roentgen therapy and condemns those modifications which various other workers have introduced merely for economy of time and expense. Only the very sensitive tumors such as the lymphosarcomas and the undifferentiated epitheliomas may be directly destroyed by the action of the radiation on the tumor cell. In the highly differentiated tumors such as epidermoid epithelioma with prickly cells predominating or tubular adenocarcinoma, the cure is effected only by evolution (that is, by slow saturation effects of these cells by radiation thus hastening their maturation and death), and it is, therefore, understandable why every effort must be made to preserve the integrity of the tumor bed of vasculo-connective tissue. When, on the other hand, this bed tissue is also destroyed, marked skin and mucous membrane changes are apt to occur with late radionecrosis.

Preliminary to instituting Coutard therapy every patient is given a complete physical examination including blood studies and such roentgen examinations as indicated, a biopsy, and a dental examination followed by the extraction of all decayed and infected teeth. To maintain nutrition the patient is given a high caloric diet and high fluid intake. Preliminary blood transfusion will help if there has been considerable blood loss. Preliminary tracheotomy is done only

when there is immediate danger of complete obstruction. Smoking and alcoholic intake are contra indicated in intrinsic and extrinsic neoplasms of the larynx during the treatment and the reaction stages. Anesthetic sprays and tablets, coal tar products, codein, barbitols, and normal saline mouth washes are prescribed freely as indicated. The writer's treatment factors are 180 kv constant potential or 200 kv pulsating, 3 to 4 milliamperes, with a filter of 2 mm copper plus 2 mm aluminum, focal skin distance from 50 to 60 cm, portals 80 to 150 sq cm, 75 to 100 r per field during the first three or four days to avoid what may be called acute sensitization of the neoplasm to the radiation. If there is no undue reaction after three or four days, 200 r measured with back-scattering is given to each of two fields daily (except Sunday) until from 3,000 to 4,000 r per field, measured with back-scattering, has been given over about 30 days. Boric ointment or nupercaine may be used to alleviate the itching and pain of the radiodermatitis.

The difficulty of making a prognosis from the size of the lesion anatomical site, and histological configuration of the biopsy specimen is stressed. External irradiation alone cannot control the majority of extensive intra-oral malignancies, hence intrinsic radium therapy or surgical endothermy are essential as supplementary treatment. The results of 26 cases of extensive intra-oral and laryngeal carcinoma treated by the above outlined procedures are given.

J E HABBE, M D

A Case of Dercum's Disease and its Treatment by Deep X-rays. Stephen K. Montgomery. *British Med Jour*, Feb 22, 1936, No 3920 pp 357, 358.

The author reports the case of a married woman 50 years of age, who complained of continuous intense pains in her legs of five years' duration, and generalized obesity of the legs of 18 years duration. Three months after the birth of her third child in 1914 she suffered from post-puerperal melancholia and her weight fell to 100 pounds. In 1918 she began to recover and in 1918 her present state of obesity began. For the last five years she had suffered intense pains in her legs. Her weight at the time of this examination was 240 pounds. Of interest was the persistence of secretion in the breasts, apart from pregnancy. An indefinite history of protrusion of the eyes and tremor of the hands was obtained.

The diagnosis of Dercum's disease (adiposis dolorosa) was made. While this condition was originally considered to be related to the thyroid gland, it has recently been established that it is dependent upon some morbid condition of the pituitary gland.

The result of irradiation therapy of Fröhlich's syndrome have been variable and in those cases in which improvement resulted the effect was believed to be due to reduction in size of the tumor and thus reduction of pressure on the pituitary, rather than to any effect on the pituitary itself. Good results were obtained in the irradiation therapy of Cushing's syndrome, basophil adenoma. No reports of irradiation therapy of

this condition were found in the literature. However, treatment was given to the reported case at eight weekly intervals employing the following factors 200 kv p, 4 ma,  $6 \times 8$  cm fields, 0.8 mm Cu + 1 mm Al filtration, right and left fields alternately. Four treatments of 140 r each were given to each port.

The results of the above treatment were considered good as the pain improved after the second treatment and eventually disappeared. The size of the patient's legs was believed to be reduced to some extent.

J N ANÉ, M D

Roentgen Therapy of Thrombo angustis Obliterans (Buerger's Disease) G E Pfahler. Am Jour Roentgenol and Rad Ther, December, 1935, 34, 770-777.

After reviewing the histology, etiology, symptoms, and treatment with results of other authors the writer states that his patients showed definite improvement of every symptom. The technic consisted of 200 kv therapy, applied over the sympathetic ganglia, indicated by the location of the disease, three times a week until a total of one half to a full erythema dose had been given over each portal or over the whole area.

Pain was relieved usually in about two or three weeks after the inception of treatment, intermittent claudication in from two to six weeks, circulatory and trophic disturbances in from four to six weeks, so that the normal color reappeared although the pulse did not return. Ulcerations disappeared within a few months, gangrene healed, general improvement was rapid, and the cachectic color disappeared.

S M ATKINS, M D

The Desensitization of the Mucous Membrane during Protracted Fractional Roentgen Therapy R Glauner. Strahlentherapie, 1930, 55, 195.

The severe reactions produced in the mucous membranes of the mouth following x ray therapy applied according to the Coutard method are often very uncomfortable to the patient. The author undertook experiments directed towards an attempt at desensitizing the mucosa in order to reduce the subjective symptoms. In eight cases of carcinoma of the floor of the mouth he applied adrenalin (1:1000) before each sitting to one side of the buccal mucosa, the non medicated side served as control. In five cases treated in this manner the radio-epithelitis did not appear at all. In two cases it was considerably decreased and one case could not be considered because no reaction appeared on either side. The beneficial effect of adrenalin is, according to the author due to the local anemia.

ERNST A POHLE, M D, Ph D

## THE SINUSES

Mucocele of the Frontal Sinus, with Special Reference to the Roentgen Aspects and Report of Four Cases. Adolph Hartung and Theodore Wachowski. Am Jour Roentgenol and Rad Ther. July 1935, 34, 30-36.

A mucocele is an accumulation and retention of a mucous secretion within a nasal accessory sinus usually associated with distention of one or more of its walls. The usual causative factors are obstruction of the nasofrontal duct or enlargement of a retention cyst. It occurs at any age. A history of trauma is often elicited. Early symptoms are varied but later findings of a slow growing, non-tender tumor in the medial upper third of the eye with displacement of the globe forward, downward, and laterally are characteristic.

Roentgen findings in connection with mucocele of the frontal sinus vary according to the stage of development of the condition. The most characteristic findings are enlargement of the sinus with pressure erosion of the walls, resulting in increased radiolucency and displacement of the boundaries, causing distortion of outline. Reactionary bone formation may be present.

S M ATKINS, M D

## THE SKIN

Influence of Roentgen Rays on Skin Capillaries. A Löw Beer and W Redisch. Strahlentherapie 1936, 55, 85.

Small fields in human skin were exposed to roentgen rays according to the single massive, fractional saturation, and protracted fractional dose methods. Photographs of the skin capillaries in the irradiated areas were taken at various intervals following the exposures (32 illustrations). It appeared that following the application of one single massive dose the reaction started in the subpapillary plexus. Following saturation a severe but rapidly disappearing reaction was seen in the capillary system. The protracted fractional exposure produced the mildest reaction.

ERNST A POHLE, M D, Ph D

The Reaction of the Skin to Roentgen Rays of Long Wave Length and to Cathode Rays. E Wilhelm. Strahlentherapie, 1930, 55, 498.

The author studied the erythema reaction of the human skin to roentgen rays produced at from 2.5 to 15 kilovolts. He found that the reaction consisted of an early erythema appearing within eight days after the exposure and a second or principal erythema appearing from three to four weeks after the exposure. The threshold doses for the early erythema increase with increasing wave length. In one person for instance, it was found at 80 r with 12 kv and at 4,000 r with 2.5 kv. The respective values for the principal erythema were 600 r at 9 kv and 20,000 r at 3 kv. Fifteen hundred r at 12 kv may produce telangiectasis, photographs of a patient's arm are shown in the article as evidence. Similar studies were carried out with cathode rays. However even after exceeding the threshold erythema dose four hundred times there appeared no late reaction. One skin area could be studied for a period of three and a half years. This phenomenon is explained with the very short length of path of the cathode rays.

ERNST A POHLE, M D, Ph D

## THE SPINE

A Case of Congenital Aplasia of the Sacrum J H Müller *Röntgenpraxis*, February, 1936, 8, 105, 106

Twenty cases of aplasia of the sacrum have been reported in the literature. Such a case is described. The first sacral vertebra is partially developed and articulates in normal fashion with the pelvis. What would normally constitute the remaining sacrum is entirely absent.

HANS W HEFKE, M D

Changes in the Posture Due to Diseased Intervertebral Discs and Their Relation to Backache Eduard Gintz *Röntgenpraxis*, February, 1936, 8, 73-87

Diseases of the intervertebral discs can only be diagnosed when there are secondary changes of the vertebral bodies demonstrable on roentgenograms or if calcification or ossification of the disc itself has taken place.

The author has shown that an abnormally straight posture may be found in the portions of the spine which are situated above certain diseases of the disc, changes which are similar to the ones described with fractures, spondylitis and congenital anomalies. It is suggested that particular attention should be paid to changes in posture, clinically as well as roentgenologically. For that reason the roentgenograms, especially the lateral ones, are made with the patient standing up and from as great a distance as possible.

In some patients who complain of backaches, such an abnormally straight posture may be found without other changes in the spine. It remains constant even when bending forward and usually comprises a circumscribed portion of the lower dorsal spine. The abnormal straightness is seen when the vertebrae are displaced posteriorly, which may happen only after damage to the discs, and in cases of osteocondrosis of the disc. This pathologic straightness without bony changes is, therefore, considered a sign of changes of the intervertebral disc. It is best explained by an increased tonus of the muscles of the back, which are used as an auxiliary brace for the pathologic portion of the spine.

In many healed processes (juvenile kyphosis, fractures, tuberculosis, etc.) which by themselves would cause no symptoms, pains may be localized above the lesion and in the area of abnormal straightness.

These observations seem to indicate that such late symptoms after the primary disease has healed are pains due to the lordosis. The same holds true in diseases of the intervertebral discs. They are pains from muscles and the periosteum and they may be also from ligaments and small joints.

Several times a calcification of the annulus of the disc could be seen in the region of the abnormal lordosis. These calcifications are probably due to the unusual tension on the disc which stimulates the deposition of calcium salts.

HANS W HEFKE, M D

Spina Bifida Occulta W Weiss *Zentralbl f Chir*, Sept 28, 1935 62, 2295-2300 (Reprinted by permission from *British Med Jour*, Dec 7, 1935, p 88 of *Epitome of Current Medical Literature*)

The author points out that systematic x-ray examinations have recently established the comparative frequency of spina bifida occulta, the first sacral vertebra being involved in 50 per cent, according to Speranski. This condition is frequently the cause of root pains after overwork or acute strain in young adult manual laborers. Not infrequently a lipoma, myofibrolipoma, dermoid cyst, or angioma in the vertebral canal is connected by a pedicle with a second similar tumor lying partly beneath the skin and partly in the cleft of the neural arch. In spina bifida the spinal cord may lie lower in the vertebral canal than is usual, and the resulting tension may cause referred symptoms. A case is described in a female factory worker, aged 20, thought to have spondylitis. Spina bifida occulta was suspected from the characteristic dimple, local hypertrichosis and absence of palpable second and third lumbar spinous processes, but even after confirmatory x-ray examination, a causal connection with the spastic paraplegic symptoms was denied, because the associated root pains and hyperesthesia corresponded to the second lumbar segment normally lying at the level of the tenth and eleventh dorsal vertebrae. Lipiodol injection showed a stop at the level of the bony hiatus, and led to laminectomy and partial removal of a lipoma extending from the first to fourth lumbar vertebrae and infiltrating the spinal cord. Much improvement followed.

A Contribution to Our Knowledge of the Fissure and Gap Formation of Atlas and Epistropheus P Geipel *Fortschr a d Geb d Röntgenstrahlen*, 1935, 52, 533-570

This excellent anatomic study contains the following chapters:

(1) A publication of 56 additional new cases of posterior fissure or gap formation of the atlas, also absence of a neural arch on one side, lateral and double fissure and gap formation in anterior and posterior arches. Furthermore, the closure of the gap is discussed.

(2) A discussion of the osseous formation of the anterior arch from mono- and binuclear anlage, in cases of absence of anterior nuclear anlage by growth of the lateral masses. Aside from normal development the numerous variances are discussed. The closure of the posterior arch during the first decade of life is illustrated, and also the fibrous bridge formation of gaps and fissures, especially in thoracopagi. Illustrations are also given of partial displacement of the posterior arch on the epistropheus.

(3) In 20 per cent of all newborn accessory nuclei of ossifications are found between the body and the roots of the neural arches of the epistropheus. The development of the "terminal ossicle" in the cephalic tip of the odontoid process is illustrated and posterior fissure and gap formation of this second cervical vertebra in earlier stages of development is shown.

The clinician regrets the absence of any remarks concerning the significance of many of these deficiencies for good function and clinical well being

H A JARRE, M D

Kyphosis Juvenilis (Scheuermann's Disease) H Scheuermann Fortschrittsber. d. Geb. d. Röntgenstrahlen 1936 53, 1-16

Kyphosis juvenilis exists most frequently in two or three vertebrae. The most apparent changes usually involve the anlage and development of the so-called limbus vertebralis as follows. The anlage of the limbus may be entirely missing. It is normally located close to the anterior edges of the vertebral body but in the presence of disturbances it not infrequently fails to reach the level of the anterior margin of the vertebral body, its form may undergo abnormal changes. The disease rarely antedates by several years the anlage of the limbus. As a result of juvenile kyphosis the affected vertebra assumes a wedge shaped disfiguration. One may consider this deformation as a compression of the ossified spongy body, combined with a retardation of growth. In addition, a prolapse of nucleus pulposus may be observed.

The prognosis of the disease never can be given reliably at the beginning of the affliction. Fixation of the kyphosis can occur within six months' time. The ultimate deformity of the vertebral body corresponds to the degree of the kyphosis. The earliest wedge shaped deformity with subsequent kyphosis was observed in a boy nine years of age before demonstrable anlage of the limbus.

Nucleus pulposus prolapse never was found in animals under normal conditions.

H A JARRE, M D

Treatment of Spondylo-arthritis Ankylopoietia by Exercising C Keiffenheim München med. Wehnschr., Feb 28, 1936, 83, 358, 359

In a review of a large series of cases of Bechterew's disease, the author shows the efficacy of prescribed exercises in the prevention of complete loss of articular motion and relief of concomitant pain. Early diagnosis is the most essential factor and symptoms suggestive of the condition are dull, continuous backpain, with stiffness and restricted motion of the vertebral column. These symptoms indicate the need for a roentgenographic examination. Such an examination may show pathognomonic evidence of the disease, with thickened or ankylosed sacro iliac synchondroses, beginning ossification of the paravertebral ligaments and periosteal proliferation along the innominate bones. Increased blood sedimentation time is significant. Roentgenoscopically marked restriction of respiratory movements is noted very early in the disease.

WILLIAM R. STRECHER, M D

Fractures of the Spine S T Irwin British Medical Jour., Jan 4, 1936, No 3913, 1-5

The author reviews a series of 34 cases of fracture of the spine which were treated in the Royal Victoria

Hospital, Belfast, during the period from 1931 to 1934. The sites of fracture were as follows: Cervical region, three cases, upper dorsal and mid-dorsal, two, lower dorsal, ten, lumbar seventeen and coccyx two. All cases of fracture of a body in this series were treated by the method of Watson Jones. The results obtained in this series were as follows: Death occurred in four cases during the first nine days after the injury, one patient died of cancer of the stomach two and one-half years after injury, one patient is paralyzed, 14 patients suffer from pain of varying intensity, and 18 patients are able to do full work.

Direct violence, indirect violence, and muscular violence are all operative in the causation of fracture of the spine. The preponderating cause however is that of indirect violence.

Fracture of the atlas results from the transmission of a force through the occipital condyles to the lateral masses. Due to the inclination of the articular facets of the atlas the effect of the transmitted force is to spread the lateral masses outward. This results in fracture of the posterior arch which is weaker than the anterior. Both arches may be involved at times. Anteroposterior and lateral films are of great value in the diagnosis.

The base of the odontoid process is the most frequent location of fracture of the axis. Fractures and fracture dislocations of the cervical spine below the axis are divided anatomically into those above the fourth cervical and those below this level. Injuries above the fourth cervical with cord lesions result in death from respiratory failure. Those injuries with cord lesions are usually pure dislocation and are easily diagnosed radiologically. In injuries below the fourth cervical associated with cord lesions, immediate death does not usually occur but paralysis usually results.

Compression fracture of a vertebral body is the most frequent type of spine fracture. The majority of these occur in the dorso-lumbar region. While the fracture may be complicated in the majority of cases injury is confined to the vertebral body. After injury the body becomes wedge-shaped with the narrow portion anteriorly, because the posterior portion is better protected by the articular processes.

Fractures of the spinous processes and laminae are due to direct violence. Fractures of the transverse process are due to muscular violence. They are unilateral and multiple and always occur in the lumbar region.

J N ANÉ, M D

## THE STOMACH

Gastric Polyp and Anemia Josef Pinke Röntgenpraxis December, 1935 7, 793-797

Polyps of the stomach may cause a blood picture very similar to that of pernicious anemia. A case which is described suffered from a rather severe degree of anemia and other symptoms of pernicious anemia. A roentgen examination of the stomach showed a polyp the size of a kidney bean in the pylorus and at other

times in the duodenum. Surgical resection showed a benign adenomatous polyp. The author maintains that not only the chronic hemorrhage from the polyp but also the disturbed cellular structure of the stomach must be considered as a causative factor for the anemia.

HANS W HEFKE, M D

## SYPHILIS

Tabetic Arthropathy and Accident. Robert Kienböck and Alfred Selka. *Röntgenpraxis*, February 1936, 8, 120-124.

It has been known that tabetic joints develop either spontaneously or after injuries. A case of a man is described, who, after falling 15 feet, suffered dislocations of both hips, which were reduced. Considerable difficulty in walking remained. Four years after the accident an x-ray examination showed very marked destructive changes in both joints, and calcifications in the soft tissues. The roentgen diagnosis was tabetic arthropathy. The patient admitted syphilitic infection in his youth, but there were no neurological symptoms of tabes demonstrable. The joint changes were, therefore, early symptoms of the tabes.

In case of compensation proceedings one would have to say that the accident was the primary cause for the joint changes, but that these changes developed so fast and so severe that they can be explained only by the pre-existing syphilitic disease.

HANS W HEFKE, M D

## THE TEETH

X-ray Absorption Coefficients of Coronal and Root Dentin. Franklin Hollander and Edmund Vesely. *Proc Soc Exp Biol and Med*, March, 1936, 34, 158, 159.

Linear x-ray absorption coefficients were measured in various parts of the dentin of four non-carious human teeth from different individuals. It appeared that the coefficient approached an upper limit in the coronal dentin of non-carious teeth and that the deviation from the maximum value tended to increase with the distance between the position of measurement and the dentino-enamel junction. Dentin formation is known to start at this junction and to proceed toward the root apices. Thus, the gradient in the x-ray absorption coefficient of the dentin appears to parallel the progress of its formation.

W A SODEMAN, M D

## THE THYROID

Results in Roentgen Therapy of Basedow's Struma with a Modified Protracted Treatment Method. W Böhme. *Strahlentherapie*, 1936, 55, 262.

During the last few years the author has tried a modified protracted fractional dose method in the treatment of thyrotoxicosis. He used 180 kv, 1 mm of Cu + 1 mm Al, H V L in copper, 1.35 mm, 60-70 cm FSD, 4.35 r per minute (in air) on three successive days. A dose of 150 r was applied over the thyroid and upper

sternum. The total dose given in several series during a period of from four to eight weeks amounted anywhere from 1,800 to 2,000 r. There were no systemic or skin reactions, so that the author feels that from 1,200 to 1,600 r can be given in from four to six weeks. From 1932-1934 a total of 91 patients were subjected to irradiation with this method, six died in the meantime but the cause of death was not connected with radiation therapy. In evaluating the results of the treatment, all factors, as, for instance, the basal metabolic rate, pulse rate, weight, and subjective symptoms were considered. Eighty-one cases were available for statistical evaluation. It appeared that 81 per cent of all cases were clinically cured. The period of observation varied from six months to two and one-half years. A comparison with the results obtained by the old treatment methods showed definite superiority of the modification described above.

ERNST A POHLE, M D, Ph D

## THE TONSILS

Roentgen Therapy of Tonsillitis. E D Dubowyn and E I Olschanowsky. *Röntgenpraxis*, February, 1936, 8, 112-115.

This is the second communication on this subject. Patients to the number of 700 have been treated, 254 are reported in both communications. All these patients have been observed twice a year for from one to three years after x-ray therapy for tonsillitis. The technique of irradiation was as follows: 210 kv, 4 ma, a filter of 0.5 mm Cu and 2 mm Al and a skin-focus distance of 25 cm. In children up to five years of age, 20 per cent of an erythema dose was given, from five to ten years of age, 25 per cent, from 10 to 15 years of age, 30 per cent, and in older persons 33 1/3 per cent (erythema dose, 640 r). Usually one or two treatments to each tonsil are sufficient. The percentage of cures in tonsillitis is 72 per cent after roentgen therapy.

This percentage did not decrease after a year or two. The roentgen therapy of chronic and recurrent tonsillitis decreases markedly the loss of time due to sickness caused by tonsillitis. Complications during and after treatments have not been observed.

HANS W HEFKE, M D

The Combined Treatment of Carcinoma of the Tonsils. P v Kisfaludy. *Strahlentherapie*, 1936, 55, 429.

The author advocates the combined surgical, x-ray, and radium treatment of carcinoma of the tonsil. He implants radium needles of 2-3 cm length which remain only from one to one and a half days *in situ*. The cervical areas receive roentgen deep therapy prophylactically (6 - 8 X 200 r), if the glands are enlarged they are removed surgically followed by x-ray therapy (10 - 18 X 180 r). In case of definite metastases in the cervical glands, they are radically resected if still in the operable stage. Radium screens are placed then in the wounds and later x-ray therapy is also given. The palliative results with this treatment method were satisfactory. During the last three and one half years

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J N ANÉ, M D

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higher voltage Ports of entry include one perineal, two iliac, and two gluteal If it becomes apparent that the patient is obtaining some relief and there is a possibility of further benefit, a second course of treatments is given about three months after the first Concerning roentgen sickness, the writer has found that 2 c c of liver extract given two or three times a week is almost a panacea for undesirable reaction

The frequency of urinary infection in these cases is stressed and emphasis is placed upon systematic effort to control or at least to minimize it

While results on the whole were far from brilliant, the writer found a number of patients responding to the extent that they obtained relief of pain and at times of the symptom of frequency (A note is also made of a small series of eight cases of benign prostatic hypertrophy which were also submitted to deep x-ray therapy, all being relieved of symptoms and considered well at the time of this report) The writer concludes with a plea for more routine pre operative radiation of these cases

J E HABBE M D

Sialography, with Particular Reference to Neoplastic Diseases H T Kimm, J W Spies, and J J Wolfe Am Jour Roentgenol and Rad Ther, September, 1935 34, 289-296

Sialography of 18 cases is presented in which a tumor occurred in the region of the salivary gland and in which a pathologic diagnosis was recorded

The technic consisted of the injection of from 1 to 15 c c of an opaque oil by means of a 2 c c Luer syringe and cannula the latter inserted into the duct, until slight discomfort was experienced in the salivary gland The roentgen examination is made immediately after the injection The cannula and syringe may or may not be left in place The discomfort disappears within a few hours

By means of this examination, in that the entire gland with its ducts could be visualized, it was possible to localize the involvement and its extent, although it could not be determined whether it was benign or malignant

S M ATKINS M D

The Roentgenologic Diagnosis of Tumors in the Sellar Region Bernard H Nichols Am Jour Roentgenol and Rad Ther, June, 1935, 33, 733-735

Fortunately for the accuracy of x ray diagnosis most tumors in the sella and its immediate neighborhood produce rather typical changes on the roentgenogram There are, however, certain sellar lesions accompanied by early eye changes and clinical evidence of tumor in which no definite changes in the bony structures of the sella occur Encephalography is definitely indicated in the suspected presence of suprasellar lesions or intrasellar lesions when there is some question as to the presence of the tumor from plain film roentgen examination

Of twelve cases of suprasellar tumor reviewed in this series two showed calcification and one showed defi-

nite sellar changes Of the remaining nine, encephalography was utilized and in seven of these the tumor was either visualized or a deformity of the ventricle was demonstrated, usually the third ventricle and of the basilar cistern In the remaining two cases the encephalogram failed to indicate the presence of the tumor The important encephalogram findings are (1) complete or partial obliteration of the cisterna chiasmatis, (2) elevation of the floor of the third ventricle or encroachment on its anterior portion, (3) separation of the anterior horns of the lateral ventricle, and (4) visualization of the tumor mass by the surrounding air in the basilar cisterna and third ventricle

There were twelve intrasellar lesions, eleven being pituitary adenomas and one a medullary blastoma Encephalography is seldom necessary in making a diagnosis of intrasellar tumor, which usually produces sufficient sellar deformity or calcification to make a diagnosis on the plain roentgenogram

J E HABBE, M D

## TUMORS (THERAPY)

Giant-cell Bone Tumor of Costal Origin Paul C Samson and Cameron Haight Jour Am Med Assn, Sept 28, 1935, 105, 1020-1023

In reporting a case of giant-cell tumor involving the second rib, proximal to the costochondral junction, on the right, these authors present clinical abstracts of seven of the nine other cases of giant-cell tumor of the rib that have been collected In four cases the tumor was posterior to the costal angle In two, the entire first rib was apparently involved, and in two the tumor was at the costochondral junction Surgical excision was done in six cases, irradiation in one, and partial excision and irradiation in one other

At present it appears that irradiation is the treatment of choice if the diagnosis can be established with certainty Conspicuous deformity may indicate the surgical removal of the tumor In the reported series no case of recurrence has been found, whether treatment was by surgical excision, irradiation or both The prognosis for cure therefore, should be good

CHARLES G SUTHERLAND M B (Tor)

Studies Regarding the Effect of Roentgen Rays on the Metabolism of Malignant Tumors K Inouye Strahlentherapie, 1936, 55, 409

The author studied the metabolism of an implanted spindle-cell sarcoma in the rabbit before and after irradiation Two different wave lengths of roentgen rays were used Half value layer in copper, 0.1 mm, for a filter of 1.0 mm Al, and half value layer in copper 0.36 mm for a filter of 0.3 mm Cu + 1.0 mm Al, 600 and 1,200 r The influence of the irradiation on the metabolism seemed directly proportional to the dose, a minimum of 600 r was required to make any change demonstrable Numerous curves are shown which indicate the fluctuations in the metabolism of the tumor cells over a period of several days The author believes that the changes in the metabolism of the meta-



a total of 40 inoperable cases belonging to this group were treated. Sixteen were alive and free from symptoms at the time of writing the report. They had been under observation for from one to 38 months. The author recommends, therefore, his combined method as outlined above in the treatment of inoperable carcinoma of the tonsils.

ERNST A. POHL, M.D., Ph.D.

## TUBERCULOSIS, PULMONARY

Selective Serial Bronchography for the Diagnosis of Tuberculous Changes of the Bronchi. Pedro L. Fariñas. Fortschr. a. d. Geb. d. Röntgenstrahlen, 1936, 53, 17-24.

This well illustrated paper shows the variety of bronchial changes which occur in the course of tuberculosis and which are demonstrable only by the introduction of a suitable contrast medium. Generally speaking, one may find pathologic narrowings and widenings of the bronchial lumina. Narrowing may be produced by extrinsic pressure, cicatrization, intrinsic pathologic contents and granulation tissue, widening may be of all types, shapes and varieties—cylindrical, sacular, and vesicular. It is very apparent that important information concerning structure and function of the bronchi can be obtained by this method which, as stated in the paper, may have to be supplemented frequently by bronchoscopic exploration.

H. A. JARRE, M.D.

A Further Contribution to the Roentgen Therapy of Pulmonary Tuberculosis. G. Cola and G. Grado. Archivio di Radiologia, 1935, 11, No. 3-4, pp. 249-279.

After a review of the literature on the roentgen treatment of pulmonary tuberculosis, the authors describe their experience with about a hundred cases they have treated by irradiation of the spleen by direct treatment of the lungs, and by treatment of the spleen and lungs combined.

They prefer the latter method and feel that roentgen therapy combined with pneumothorax is the best method of treating pulmonary tuberculosis. Roentgen therapy is indicated in the proliferative fibrotic and glandular types in which it gives brilliant results.

E. T. LEDDY, M.D.

Pathology of Childhood Tuberculosis. Chester R. Brown. Jour. Med. Soc. of New Jersey, February, 1936, 33, 77, 78.

The author traces the pathology of childhood tuberculosis in the respiratory tract through the stages of primary solitary pulmonary focus, perifocal inflammation, and lymphatic spread. He describes the x-ray findings in these various stages and stresses the technical and anatomical difficulties of x-ray diagnosis. He concedes that thoracic lesions are diagnosed in only 20 per cent of positive Mantoux tests, and, therefore, serial plates as well as close co-operation between the roentgenologist and the physician in charge of the case are recommended.

W. H. GILLEN, M.D.

## TUMORS (DIAGNOSIS)

Roentgen Diagnosis of Malignant Duodenal Tumors. Zoltan von Hrabovszky. Fortschr. a. d. Geb. d. Röntgenstrahlen, 1935, 52, 580-594.

This paper is based on the observation of three carcinomas and one sarcoma of the duodenum. It gives a very interesting review of the literature and arrives at the following conclusions:

(1) Carcinoma of the papilla of Vater can be demonstrated roentgenologically before a stenosis occurs.

(2) Infiltrating neoplasms transform the duodenum into a rigid tube which in case of carcinoma, shows a rather irregular ragged narrowing for a short distance, in cases of sarcoma, usually for a longer stretch. With advancing growth of the tumor the lumen may later enlarge. It appears that infiltrative neoplasms produce stationary longitudinal duodenal folds while superficial infiltration of the mucosa produces a coarse, stationary transverse formation of folds, in both types of tumor the normal, very characteristic and active duodenal motility, with the perpetual change in the apparent relief, is changed to a frozen appearance.

H. A. JARRE, M.D.

Cholesteatoma. Lewis J. Friedman. Am. Jour. Roentgenol. and Rad. Ther., July, 1935, 34, 37-40.

Three cases are presented, two of which have been verified by the pathologist. This pearly tumor is a rare benign, squamous-cell, epithelial neoplasm usually containing cholesterol crystals. This tumor is fairly frequent in the mastoid. Microscopically, the tumor is composed of flattened epithelial cells mixed with cholesterol crystals.

Roentgenologically it appears as a punched-out area of decalcification in the skull, polycystic, with dense trabeculae between the cysts and well circumscribed. It is invasive but does not expand the tables of the skull.

The growth of this lesion is insidious and produces symptoms by mechanical pressure when it occurs in the skull. In the mastoid it produces a persistent aural discharge.

S. M. ATKINS, M.D.

Deep Roentgen Therapy of Carcinoma of the Bladder and Prostate. A. T. Nisbet. Am. Jour. Roentgenol. and Rad. Ther., June, 1935, 33, 807-809.

The large majority of the cases of carcinoma both of the bladder and the prostate referred for roentgen therapy were in advanced inoperable stages of the disease. A number of the patients were unable to complete a course of x-ray treatment and died within three months of being first seen.

Concerning technic of radiation, the author notes that this has varied somewhat in recent years. The older technic utilized 190 kv. and 1 mm. copper, whereas during the last nine months as much as 3 mm. Cu and 250 kv. have been utilized. The increase in roentgens delivered to the skin has risen from 1,200 r in the earlier days to 2,000 r with the heavier filtration and

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## UNUSUAL PERIOSTITIS IN CHILDREN

By CASSIE B ROSE M D , Presbyterian Hospital, Chicago

THESE five cases are reported, first, because of the close similarity of the x-ray and wide divergence of the clinical findings, second, to emphasize the value of co-ordinating the history and clinical findings in the interpretation of

Hospital of the City of Chicago, and two from the Central Free Dispensary of Rush Medical College of the University of Chicago

All of the patients are children, ranging in age from six months to four and one-



Fig 1 A

Fig 1 A Case 1 Fusiform elevation of periosteal new bone of humerus with well defined shaft slightly more dense than normal

Fig 1 B

Fig 1 B Case 1 Film taken shortly after sequestered shaft was removed en masse through incision in the involucrum

x-ray evidence, and third, because of the comparative rarity of some feature of each of these cases

Three patients are from the Presbyterian

half years Their x-ray films show on the shaft of long bones a fusiform elevation of periosteal new bone with dense, sharply defined calcification at the outer margin,

diated tumor tissue are due to an iajurious effect of the roentgen rays. The metabolism after irradiation approaches that observed in tissue undergoing degeneration.

ERNST A. POHLE, M.D., Ph.D.

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Experiments in the Combined Roentgen and Heat Therapy of Malignant Tumors. Kristian Overgaard. *Acta Radiologica* 1935, 16, 461-470.

The author presents experimental evidence, obtained by work on white mice, to show that diathermy and roentgen radiation may be effectively combined in such a way for the treatment of malignancies that subtherapeutic doses of the two may have an additive complementary effect, producing an electric tumoricidal result.

E. M. SHENESTA, M.D.

### ULTRA-VIOLET LIGHT

Studies of Protective Ointments for Ultra violet Radiation and Related Principal Problems. J. M. Eder and L. Freund. *Strahlentherapie*, 1936, 55, 560.

The authors undertook an extensive investigation of ointments available as protection against the erythema producing rays of the sun and artificial sources of ultra-violet light. They come to the conclusion that biologic tests are not reliable. They consider the entire range from 2,300 to 3,950 Å as effective on the skin.

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The maximum erythema effect in the quartz mercury vapor lamp is between 2,970 and 3,130 Å, for the sun between 3,000 and 3,500 Å, and for the carbon arc between 3,000 and 3,950 Å. A preparation called "Antilux" appeared to be superior to all other investigated ointments. It provides sufficient protection for ultra violet rays from 3,100 to 3,500 Å. This ointment also reflects radiation around 3,130 Å.

ERNST A. POHLE, M.D., Ph.D.

### THE UTERUS

The Changes in the Blood of Women with Cancer of the Uterus after the Use of Vaccine Broth and Radium and X-ray Treatment. A. M. Bonanno. *Archivio di Radiologia* 1935, 11, No. 3-4, pp. 325-344.

Administration of vaccine tends to diminish the infection present in the cervical carcinoma and thereby the leukocytosis of the patient is reduced. During radium treatment the red cell count tends to improve, the white cells to behave in a varying way. After the vaccine, the polymorphonuclear cells tend to decrease. After combined radium and X-ray treatment there is a decrease in the leukocytes and to a less extent in the erythrocytes and hemoglobin. Shortly the blood returns to normal. Changes in the blood by themselves, seem to have no definite prognostic significance as they are changes secondary to the uterine cancer.

E. T. LEDDY, M.D.

The swelling subsided and a discharging sinus persisted. After ten weeks there was a recurrence of swelling and inflammation and increased discharge, at which time the child entered the hospital.

Combining this history with the x-ray findings the diagnosis of osteomyelitis is practically certain, and the operation confirmed this diagnosis. The sequestered shaft was removed *en masse* through an incision in the involucrum. A satisfactory new shaft formed later.

Case 2. The x-ray film of this year-old Lithuanian child shows periosteal new bone the entire length of both femurs, more markedly elevated in the upper half of each shaft, where it rises to a maximum of two centimeters. Subepiphyseal bone absorption has led to displacement of the shaft at the upper end of both femurs. All of these changes are a little more marked on the right side and there is also marked swelling of the soft tissues of the right leg. The tibiae and fibulae show these changes in a less marked degree, accompanied by slight thickening of the metaphyseal margins. The distal epiphysis of each radius and ulna is dense, and there is no bone absorption, or periosteal new bone along the shafts.

These x-ray findings strongly indicate scurvy, because of their character and their multiplicity, and the age of the patient. It is a severe scurvy, complicated by fractures, and with large subperiosteal hemorrhages which now show calcification. Yet why is there swelling of the right leg? Had this leg only been rayed, the findings would closely simulate the osteomyelitis of the last case. Indeed, when the child came to the dispensary, the clinical findings were entirely referable to the right femur, and very suggestive of osteomyelitis.

The right leg was swollen, red hot, and painful. It did not pit on pressure. The other extremities were not swollen, nor discolored, and did not seem to be painful. The child's temperature was 102.4 degrees.

The history revealed that three months previously while teething the baby had a

severe diarrhea, with six to ten greenish stools per day. Four weeks later, after being chilled while out-of-doors, the baby's legs, thighs, right arm, and areas under the eyes became edematous. The swelling, except that of the right leg, had disappeared two weeks before coming to the clinic.

The mother refused to hospitalize the child. Dietary measures, including orange juice, were prescribed. The mother did not bring the child to the clinic again. A Social Service worker found that the child died at home two weeks after the visit to the Clinic.

Was this *only* scurvy? If so, why had the swelling remained in the right leg, or was there really an osteomyelitis in this leg superimposed on a scurvy?

Case 3. The films of this 18-months-old white girl show elevation of periosteal new bone for from 2 to 7 mm above the entire shaft of the right ulna and the upper third of the left ulna. There is a homogeneous calcification between the shaft and the periosteal margin. The shaft is distinctly visible and unchanged. In addition, five bones in the hands and two in the feet show irregular destruction of the shaft and heavy irregular periosteal new bone, with flask-like swelling of soft tissues, all of which, when associated, are characteristic of tuberculous dactylitis.

The tuberculous dactylitis at once suggests that the lesions of the ulnas are also tuberculous, although the changes described in the ulnas are rare in tuberculosis, and especially in children. The periosteal reaction of syphilis is suggested, although unlikely since other bones are not involved. Rickets and scurvy are ruled out because of the absence of epiphyseal involvement. Subperiosteal hemorrhage without fracture, or osteomyelitis without involvement of the shaft, are illogical, especially since such lesions almost never involve two bones in about the same degree, such as occurs in this patient.

This child, one of twins, weighed six and one-half pounds at birth and seemed normal. It was breast-fed for three months, and afterward with various milk mixtures



Fig 2-A

Fig 2 A Case 2 Film shows periosteal new bone the entire length of both femurs more markedly elevated in the upper half of each shaft, where it rises to a maximum of 2 centimeters. Subepiphyseal bone absorption has led to displacement of the shaft at the upper end of both femurs. All of these changes are a little more marked on the right side and there is also marked swelling of the soft tissues of the right leg. The tibiae and fibulae show these changes in less marked degree accompanied by slight thickening of the metaphyseal margins.

Fig 2-B

Fig 2 B Case 2 Film of right upper extremity shows increased density at the epiphyseal margin of the lower end of the radius and ulna and slight thickening at the upper end of the humerus. There is no bone absorption and no periosteal new bone along the shafts.

which gradually decreases in density to the shaft. The bone shaft is distinctly visible and shows only slight change from normal. The lesions extend either a part or the entire length of the shaft. In four cases the lesions are multiple.

In the differential diagnosis of these cases from an x-ray standpoint, one must consider some process which is found in children, and which will elevate the periosteum. Hemorrhage or pus beneath the periosteum, such as can occur from trauma, scurvy, or osteomyelitis, a syphilitic or a rachitic periostitis, occasionally tumor, and more rarely tuberculosis, are lesions of this type.

Case 1 This is a white male child, six months old. A film of the right arm shows on the humerus a fusiform elevation of periosteal new bone from one epiphyseal line to the other, rising to a maximum height of one centimeter above the shaft. The calcification beneath the periosteum is homogeneous in character and gradually

fades out toward the shaft, which is well defined and slightly more dense than normal. The bones of the forearm are atrophic, otherwise normal. There is swelling of soft tissues of the upper part of the arm.

From the x-ray film alone, scurvy, rickets, and probably syphilis can be ruled out because the lesion involves only one bone. Trauma rarely makes such marked changes without definite evidence of a fracture, which is lacking here. The lesion is rather old, as the new bone is fairly dense, and also the shaft is dense, which suggests that it is sequestered. Two points are uncommon for osteomyelitis: one, the very young age of the patient, the other, the sequestration of an entire shaft without irregular erosion of the shaft.

The history was that, at three months of age, the child had whooping cough followed by a left-sided pneumonia. While recovering from the pneumonia, the right arm became swollen and tender, and after two days was incised near the shoulder.



Fig 4 Case 4 Films show a fusiform periosteal elevation of 5 mm (maximum height) over the lower half of each humerus and the upper half of each ulna and the entire metacarpal of the left index finger. There is a laminated fairly dense calcification between the shafts and the periosteal margins. The shafts are distinctly visible and unchanged. The mid part of the right tibia was similarly involved.

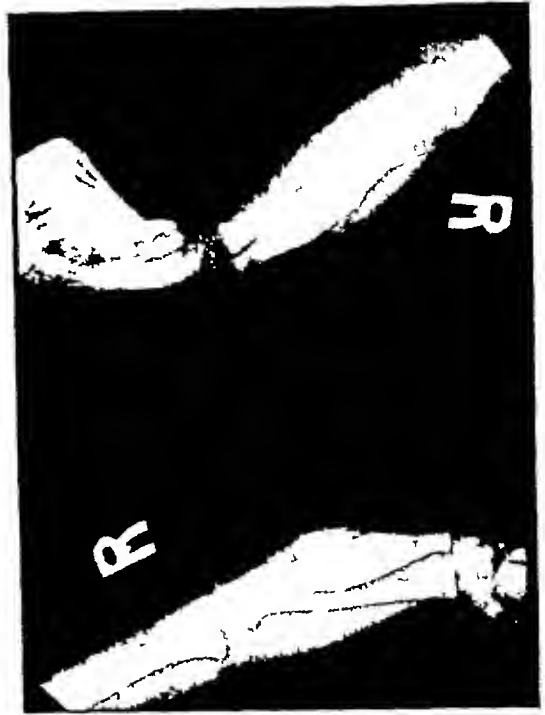


Fig 5 A Case 5 Anteroposterior and lateral views of the right forearm show periosteal elevation of the entire right ulna.

type" of pus and several small bone fragments were removed. Cultures showed a very scanty growth of pyogenic organisms, none of tubercle bacilli. Microscopic sections showed tuberculous tissue, with many giant cells. This evidence confirmed the clinical and x-ray diagnosis of multiple tuberculous dactylitis, and, because of this evidence, the fusiform periosteal elevation in both ulnas was believed to be tuberculous in nature, although not examined microscopically.

Case 4 This is a white child, four and a half years old. Films show a fusiform periosteal elevation of 5 mm maximum height over the lower half of each humerus and upper half of each ulna and the mid part of the right tibia. There is a laminated fairly dense calcification between the shaft and the periosteal margin, while the shaft itself is distinctly visible and un-

changed. The entire metacarpal of the left index finger is similarly involved. The right tarsal scaphoid is small, dense, and irregular—a characteristic Kohler's disease. The unaffected portions of the involved bones, as well as all other bones of the extremities, are normal.

The laminated periosteal thickening of one metacarpal and five other long bones is very suggestive of a syphilitic lesion. Involvement of about half of a shaft, with the other half normal is not uncommon in the syphilis of children, especially in the very young. This child is rather old for this type of lesion, still it *might* be a *lues tarda*. Rickets and scurvy can be ruled out by the absence of epiphyseal line changes, and osteomyelitis because of the uniformity of the involvement in several bones simultaneously. In view of the peculiar manifestation of tuberculosis in the previous case, the possibility that these lesions might also be tuberculous was not forgotten, but could not be proved from the x-ray examination alone.

and infant's foods. There were occasional attacks of diarrhea, but no other illnesses until about four months before entering the

At this stage the child entered the hospital. Although fairly well nourished, the child was fretful and looked ill. There was no



Fig 3 Case 3 Film of upper extremities shows elevation of periosteal new bone extending from 2 to 7 cm from the entire shaft of the right ulna and the upper third of the left ulna. Five bones in the hands show irregular density of the shaft and irregular periosteal new bone with flask-like swelling of the soft tissues, characteristic for tuberculous dactylitis. Two bones in the foot were similarly involved.

hospital. Then, at 14 months of age, there occurred swelling in multiple areas of the hands, and in both ankles, corresponding to the sites of the bone lesions shown later on the films. The swollen members gradually enlarged to one or two inches in diameter, became red, tender, slightly fluctuant although not particularly painful. From several, a sero-purulent discharge exuded

fever. The von Pirquet test was strongly positive.

Nothing in the child's history or physical findings suggested the bone lesions which were found in the ulnas by x-ray examination.

The swollen areas of the hands and ankles were incised and a considerable amount of grayish-yellow, "tuberculous

negative The child was next seen when 11 months of age, at which time a fluctuating swelling of two or three weeks' duration was present over the right forearm, with smaller swellings near the right knee and on the right foot The swollen areas were moderately tender, not red, and did not seem acute The Wassermann test at this time was strongly positive Anti-syphilitic treatment was instituted, and continued for four months Films taken after three months of treatment show a very slight increase in the bone density of the involved areas, otherwise no change The soft tissues, however, had ulcerated in the areas of previous swelling The von Pirquet test was negative at this time and the Wassermann again strongly positive The mother's Wassermann was also positive

From all of this evidence, both clinical and from x-ray films, a congenital syphilis, with secondary osteomyelitic infection, was considered as the most probable diagnosis, and removal of the sequestrum in the ulna

was advised This was not carried out, however, as the parents were leaving for the South and the child did not remain for further observation and treatment

#### SUMMARY

In conclusion, I wish to emphasize that x-ray findings which are strikingly similar, may, in reality, be due to widely different clinical conditions, as proved by clinical and pathologic evidence

An interpretation, based on x-ray findings alone, may lead to a wrong diagnosis, especially in unusual cases, if the clinical history and the pathologic findings are not considered, and even after a most careful study one may still be in doubt, as in two of the cases here reported

Unusual change in one bone should stimulate the study of other bones of that patient

My plea is for the close co-operation of the clinician and the roentgenologist for the good of the patient

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Fig 5-B Case 5 Anteroposterior and lateral views of the right lower extremity show periosteal elevation in the mid part of the fibula and in the right fifth metatarsal

The new bone beneath the elevated periosteum is loculated especially that of the ulna. The bone shafts although slightly atrophic are fairly well shown through the periosteal new bone. There is a little associated swelling of soft parts especially over the ulna. All other bones are normal.

This child, a mongolian idiot, with a cleft palate, came to the hospital because of swollen glands of a year and a half duration, and recent convulsive attacks, with occasional loss of consciousness. The glands of the neck had become enlarged three months after the breaking of a tooth, and had remained large ever since. One gland had become red and sore, was incised, and had drained pus for six months. On examination of this child, the cervicals, inguinals, and epitrochlears were all palpable and ranged in size from bird shot to that of a pea. Healed keloid-like scars were present in each submandibular region. Marked thickening of the arms and legs could be palpated, especially of the humeri and the left tibia.

The von Pirquet was strongly positive, basal rate was  $-14$ , leukocyte counts varied from three to eight thousand

A biopsy of a cervical gland and the right tibia was done. The cultures and guinea pigs were reported negative for tuberculosis. The microscopic sections of both the gland and the tibia showed findings which were considered to be tuberculous. It was believed, therefore, that all these bone lesions were tuberculous in nature.

Tuberculous osteomyelitis of the long bones in children is rare, and I am fortunate to be able to present these two cases.

**Case 5** This is a colored child, 18 months old. Films show periosteal elevation of the entire ulna, the middle of the right fibula, and the entire right fifth metatarsal. The new bone beneath the elevated periosteum is loculated, especially that of the ulna. The bone shafts, although slightly atrophic, are fairly well shown through the periosteal new bone. There is a little associated swelling of soft parts, especially over the ulna. All other bones are normal.

Osteomyelitis may be multiple, and should be considered. Against it is the fact that the lesions are all in practically the same stage, and also that one lesion is in the middle of a shaft away from the entrance site of the nutrient vessel. The lesion in the foot strongly suggests a tuberculous dactylitis, and, therefore, the other two may also be on a tuberculous basis. Syphilis is sometimes localized, or focal, in its manifestation, but rarely is there so pronounced a local lesion involving three areas, and not involving other bones also. The associated swelling of the soft tissues could fit either with osteomyelitis or tuberculosis, and perhaps also with syphilis. Absence of epiphyseal changes rules out rickets and scurvy. Bone cysts are rarely multiple. Fibrocystic disease or myeloma usually involves the shaft rather than the periosteum. Periosteal tumors are rare in children and almost never multiple.

The history reveals that this child was seen in the Central Free Dispensary when one month of age, and seemed normal except for a palpable right epitrochlear gland. The Wassermann test was then

among them, Lenard At various times, Lenard very cordially gave valuable information regarding the circumstances surrounding the discovery of the roentgen rays, but in his letters, as well as in his printed communications on the subject, he frequently hinted at some as yet unknown connection between the discovery proper and the part which he played in it On Aug 18, 1929, he wrote, for instance, in a personal communication "There is no doubt that the road to the discovery led over my researches At that time I was prevented by external circumstances from pursuing to my satisfaction in every direction the great number of new phenomena which appeared in my studies on cathode rays But in my opinion, this is not yet the proper time to express myself more thoroughly on the subject than I did in my Nobel prize lecture (6) That would be only biographical anyway and what has already been said must suffice for the judicious With this I believe that I have done everything that the history of science can expect of me on this point at this particular time" In a previous publication (7), during a controversy about the discovery, Lenard also intimated that perhaps more data in regard to the discovery might be produced at a later date

Both Stark (2) and Schmidt (3) in their recent statements may now have furnished the information to which Lenard referred many years ago Stark (2) presents copies of the original correspondence in 1895 between Lenard and Röntgen regarding the acquisition of the Lenard tube from the glass technician, Müller-Unkel, then analyzes the circumstances surrounding the discovery and comes to the definite conclusion that Röntgen must have used the Lenard tube when he made his discovery Stark then enumerates three important experimental conditions which favored Röntgen rather than Lenard in preparing the ground for the discovery (1) Röntgen had obtained the best Lenard tube available, (2) Röntgen surrounded his tube with black cardboard, which reduced the intensity of the then unknown  $\gamma$ -rays much less than

the zinc box which Lenard always used to shield his tube, (3) Röntgen used in his observations on cathode rays, a barium platinocyanide screen, which responds much more to  $\gamma$ -rays than the pentadecylparatolylketone screen which Lenard used Thus, Stark concludes that under the given experimental conditions, it was inevitable that Röntgen should make his discovery

J Schmidt's (3) paper, which appeared in the "Physikalische Zeitschrift," immediately follows Stark's publication and describes his successful attempts to demonstrate the existence of x-rays near the platinum seal window of a Lenard tube, using an exact replica of the one which Röntgen bought from the firm of Müller-Unkel prior to his discovery This proof also includes a study of the efficiency of various fluorescent screens Schmidt explains again that Lenard, in his investigations of cathode rays, observed certain strange phenomena, the investigation of which he postponed, however, in order to study more thoroughly the primary objects of his interest, the cathode rays, thus Lenard missed the interpretation that these strange phenomena were due to a hitherto undiscovered kind of rays Both Schmidt and Rossler (4) conclude their articles in a vein similar to that of Stark's article

On the other hand, the view that Röntgen used a Hittorf-Crookes tube at the time of the discovery has been and is held by many I proposed this view in my book on Röntgen (1) after having closely examined several sources for this report One of the most reliable of these sources comes from L Zehnder, who was a good friend of Röntgen and his assistant and co-worker for many years Zehnder definitely states in his recent book (8), "Letters of Röntgen and Zehnder," that Röntgen used the Hittorf tube when he discovered the  $\gamma$ -ray Zehnder's own words are "When I saw Röntgen after the discovery, he told me that he discovered the rays with the Hittorf tube and not with the Lenard tube Friends of Lenard are spreading the myth that Lenard was the real discoverer of the roentgen rays, and they believe that Rönt

# WHAT KIND OF TUBE DID RONTGEN USE WHEN HE DISCOVERED THE X-RAY?<sup>1</sup>

By OTTO GLASSER, PH D, Cleveland Clinic Foundation, *Cleveland, Ohio*

FEEL that we should not let this great meeting at which we heard so many excellent reports on the use of the roentgen rays go by without calling attention to the fact that we celebrate this year, the fortieth anniversary of the discovery of the x-ray or roentgen ray. Forty years have passed since Wilhelm Conrad Röntgen, Professor of Physics at the University of Würzburg, saw a strange phenomenon—the bright fluorescence of some barium platinocyanide crystals near an excited evacuated tube. He pursued the study of this effect in a most masterly and thorough manner, and discovered it to be due to a "new kind of rays," which he called the "x-rays."

Many stories and fables have been woven around this famous discovery, some of which I have attempted to unravel in my book on the life of Rontgen (1). Even now, forty years later, discussions about the details of the discovery continue. Only recently, a discussion was again begun about the type of tube which Rontgen used when he made the discovery. Several articles have appeared in the last few months in German journals attempting to prove that Röntgen's work with a Lenard cathode-ray tube and not with a Hittorf-Crookes tube, led to the discovery. The titles of three of the communications are "On the History of the Discovery of the Roentgen Rays," by J. Stark (2), President of the Physikalisch-Technische Reichsanstalt, "On the Roentgen Rays Emitted from the Platinum Seal of a Lenard Window Tube," by F. Schmidt (3), Professor of Physics at Lenard's Heidelberg Institute, and "On the Discovery of the Rays Named after Rontgen," by O. Rössler (4), a Baden-Baden pharmacist and former co-student of Lenard.

<sup>1</sup> Presented before the Radiological Society of North America, at the Twenty-first Annual Meeting in Detroit, Dec. 2-6, 1935.

The tendency in these articles is to credit Lenard, the famous Heidelberg physicist.<sup>2</sup> This is perhaps best summarized by Rössler in his short article in the *Münchener Medizinische Wochenschrift* in which he states "In 1895, Röntgen became very much interested in Lenard's work and experiments, and asked Lenard to assist him in the repetition of these experiments. Lenard had built his first tube himself but then had ordered an improved tube from a shop for physical instruments. Since this tube was expensive, and since Lenard had only a very moderate income, he could not acquire it. He, therefore, wrote to Rontgen and asked him to buy this instrument with which he could make further studies. Rontgen did so and was able to find with this tube those rays which have become so useful in practical medicine." These statements which link the name of Lenard with that of Röntgen in the history of the discovery unfortunately come at a rather late date. They should have been proposed while Rontgen was still alive. However, they recall some remarks which Lenard made on various occasions in past years.

Phillip Lenard, who is now Emeritus Professor of Physics at the University of Heidelberg, is one of the few surviving predecessors of Rontgen in the genealogy of x-rays (5). There is no doubt but that Lenard's outstanding investigations on the various properties of cathode rays formed the most significant basis for the discovery of the roentgen rays, a fact which Rontgen mentioned in his first communication, by speaking of Lenard's "wonderful experiments."

When I began to collect the material for my historical studies on the roentgen rays, I wrote to many of the early pioneers and,

<sup>2</sup> A rather mysterious article with similar suggestions was written by one Erhard Griener and appeared in the March 1, 1935 issue of the *Zürcher Illustrierte Zeitung*. It is however so full of untruthful statements that it is not worth while to discuss it here.

## DILATATION OF THE PULMONARY ARTERY OF CONGENITAL ORIGIN

By LESTER A. SMITH, M.D., WALTER P. MOENNING, M.D., and GEORGE S. BOND, M.D., *Indianapolis, Indiana*

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A MODERATE degree of increase in the diameter of the first portion of the pulmonary artery occurs in numerous conditions, although it is not mentioned frequently in reports of roentgen examinations. However, communications regarding marked generalized broadening of the artery or aneurysmal dilatations are infrequent in the literature and actual aneurysms of this vessel are very rare. Little attention has been paid by American roentgenologists to the radiologic criteria for diagnosis of abnormalities affecting this structure. In one patient coming under our observation, particular interest was attached to his condition because of the marked degree of dilatation of not only the main stem but of the branches, the lack of recognition of the underlying congenital defects at previous examinations, the clinical course during a period of observation, and the autopsy findings. In another, aneurysms of the pulmonary artery of congenital origin were found at autopsy after repeated examinations by various consultants had failed to yield the correct diagnosis.

### CASE REPORTS

Case 1. H. Y., white male, aged 38 years, came for a roentgen film study of the chest on account of the clinical findings by one of us (W. P. M.) of slight cyanosis, cardiac enlargement, and a presystolic murmur, heard best at the left nipple. His primary complaint was intermittent nasal obstruction which had begun in early life, but also he had long been bothered by coldness and discomfort in the feet. Although throughout his childhood he had been rather frail and had some dyspnea on exertion, he engaged in fairly strenuous physical activities in play and farm work.

Upon college entrance he was barred by the university physician from college athletics because of "heart disease," a diagnosis later confirmed by other physicians, but he had regarded neither this nor the diagnosis of pulmonary tuberculosis which was made when he was 26 as of serious import. The history was otherwise irrelevant.

*Physical Findings*—The lips, nails, and cheeks were slightly cyanotic. A turgescent rhinitis was present. The chest measured 36 inches on inspiration, 33.5 inches on expiration. The heart was enlarged, with the apex impulse at the seventh interspace in the axillary line. There was a snappy pulmonic second sound, plus a presystolic murmur heard best at the nipple. Auscultation and percussion of the chest and the other physical findings were of no particular significance.

The blood pressure was 140/80. Urine examination was negative. Hemoglobin, 100 per cent, red blood cells, 6,112,000, white blood cells, 9,900, with a distribution of 80 per cent neutrophils, 14 per cent lymphocytes, 4 per cent eosinophils, and 2 per cent monocytes.

Roentgen study revealed a globular heart, greatly increased to the right and left, with much broadening of the pulmonary trunk markings (Fig. 1).

Three years later the man returned on account of pain of three weeks' duration, located in the region of the anterior ends of the left second and third ribs, aggravated by cough or deep inspiration. The heart as studied radiographically was a little increased in size over that found in the former examination.

He was seen again eight months later, when there were clinical and roentgen evidences of lobar pneumonia in the upper lung-field on each side. Fluoroscopically,

gen, working with the Lenard tube, did not discover anything essentially new, even though Röntgen in his famous original communication (9) on the x-ray spoke first of the Hittorf tube and mentioned the Lenard tube only in second place. One must always remember that Röntgen was extremely careful in his scientific statements."

Are these two points of view in regard to the tube used at the time of the discovery irreconcilable? I believe that they are not. A careful analysis of the situation would seem to present the following picture. Röntgen himself stated (1) that he became interested in the problem of cathode rays from vacuum tubes as studied by Hertz and Lenard, and that in October, 1895, he began to make researches of his own. There seems to be little doubt but that in these early experiments he used the Lenard tube described above. It is probable that in investigating the cathode rays emitted from this tube with his barium platinocyanide screen, he found that he obtained an effect at distances and angles greater than those described by Lenard. This made him look for similar effects on windowless tubes which, according to previous experience, did not permit the cathode rays to penetrate the wall and reach the outside air. Such a windowless tube was the Hittorf or Crookes tube. Still, he observed effects on his screen also with these tubes. Since the properties of cathode rays known up to that time did not account for the effect, Röntgen realized that he had to deal with either

a type of cathode rays of hitherto unknown penetrability, or with a new kind of ray. His thorough researches which proved that they were the latter are well known and need not be repeated here.

The new material brought forth by Stark and Schmidt is valuable since it gives a better insight into some phases of the actual discovery. As far as their conclusions are concerned, I feel that they have to be modified to the degree explained above. Whichever of the two tubes was actually used in the first crucial observation which made Röntgen feel that he had something new, really does not matter. The discovery itself is one of the greatest of all times and the discoverer has earned immortal fame.

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recent pneumonic process existed in each lower lobe, that in the left surrounding a bronchiectatic abscess. The only obvious immediate cause of death was the pulmonary thrombosis.

Case 2. P. W., white male, aged 30 years, was brought by his father, a physician, for consideration of roentgen therapy on account of a mediastinal tumor. He had always had "lung trouble." His cough was very annoying and there was much dyspnea and substernal pain. Numerous physicians had been consulted, including those at a large general clinic. The first roentgen study of the chest had been made two years previously, when a large mediastinal tumor was found, the nature of which had never been determined.

Radiographs of the chest were made at this time (Figs 2 and 3), the previous radiographs were not available for comparison. As studied in the postero-anterior projection, there was seen a much enlarged heart shadow, the increase being chiefly to the left. Fusing with the upper part of the cardiac shadow and extending outward into the left pulmonary field was a rather rounded, non-pulsating mass. Extending outward into the right pulmonary field, two-thirds the width of the right chest, was another, larger mass, also without expansile pulsation. The aortic arch was not demonstrable in this projection. The trunk markings in the pulmonary fields were increased moderately over the normal, more so on the left than on the right. The trachea was displaced appreciably to the right, at and just above the level of the bifurcation.

Study in the right anterior oblique plane gave evidence of a considerable degree of anteroposterior increase in the cardiac diameter. The normal outlines of the upper portion of the heart and the aortic arch could not be distinguished. In this and in the left lateral view there was evidence of a large tumor mass superimposed upon the structures in this vicinity with a rounded superior margin. Extending to the right posterior from this tumor mass

was a projection of large size which reached from the level of the sixth dorsal vertebral body to that of the tenth.

The patient's condition steadily grew worse, and Dr. Bond was consulted. All medical therapy failing, exitus occurred fifteen months after our examination.

Autopsy was performed by Dr. H. M. Banks, to whom we are indebted for the necropsy report.<sup>1</sup> The pulmonary artery was found to be greatly distended, with a diameter of 5 cm. in its main portion. There were fusiform dilatations of the right and left branches just beyond the bifurcation, extending well out into the lungs, that on the right being 8 cm. in diameter, and on the left, 6 centimeters. The walls were markedly thinned and the lumen filled with a canalized, lamellated clot. Much dilatation of the pulmonary veins had resulted from pressure by the masses. No evidence of congenital defect of the heart was found but it was enlarged to about three times the normal size, the increase being in the right chambers. The valves were normal. Much parenchymatous fibrosis and sclerotic obliterative arterial changes were found in the lungs.

Contributions in the literature have dealt mostly with changes in the main stem of the pulmonary artery, there being relatively few comments upon the roentgenologic demonstration of enlarged distal branches. The literature upon aneurysm of the pulmonary artery has been extensively reviewed by Henschen, Posselt, and, more recently, by D'Aunoy and von Haam, who have analyzed most of the reported cases as to age, sex, anatomic findings, etiology, and associated abnormalities in the circulatory system. D'Aunoy and von Haam account for a total of 87 instances reported with autopsy findings since 1833 and give an excellent bibliography upon the subject. Since their article appeared, Joules, Scott, and Holst have reported upon the condition. They have omitted reference to the reports of Balaban and Pokidoff, Dietrich, Posselt, Kranz,

<sup>1</sup> The complete autopsy findings will be reported elsewhere by Dr. Banks.



Fig 1 Case 1

a striking appearance was presented by the combination of the two conditions with a definitely expansile pulsation of the large vascular structures seen in optical section in the pulmonary parenchyma

Radiographic study nine months later gave the same findings as at the first study 52 months previously. Five months after this fourth and last roentgen examination, he re-entered the hospital with symptoms of infection in each lower lung-field. His endurance had been below par for the preceding year. The cardiac apex extended 3 cm to the left of the midclavicular line. Exitus occurred suddenly in an attack of extreme cyanosis seven days after the onset of acute symptoms. The clinical and roentgen diagnoses of the condition here considered were congenital dilatation of the pulmonary artery arising on the basis of a congenital cardiac defect.

Necropsy, performed by Dr Wemple Dodds, revealed a very greatly enlarged heart weighing 663 grams, which extended 8 cm to the right of the median line and 12 cm to the left, being greatly hypertrophied throughout but especially in the right chambers. There was congenital absence of the interauricular septum, making the heart trilobular. The mitral valve was slightly stenosed, with sclerotic changes. The aortic, tricuspid, and pulmonary valves were normal. Atheromatous



Fig 2 Case 2



Fig 3 Case 2 Right anterior oblique projection

changes were of moderate degree in the aorta, being much more marked in the pulmonary artery and its branches, with numerous atheromatous ulcers in the main trunk. The pulmonary artery was congenitally dilated throughout, the main trunk being 5 cm in diameter. Antemortem thrombosis was present in all the arteries of the left lower lobe. The pulmonary veins were markedly dilated. Lung changes, secondarily of congenital origin, where chronic emphysema and chronic passive congestion with bilateral chronic interstitial pneumonia. A more

peatedly mentioned as a factor Increase in pressure in the pulmonary artery can result from a patent ductus, a congenital cardiac lesion such as a septal defect, or a mitral lesion with its resulting back-pressure Peck considers approximately 25 per cent of reported cases to have been syphilitic in origin Trauma has been considered the cause in several (5 and 14), and congenital defects in the wall of the artery have been rated as important by Costa However, congenital anomalies of the heart or imperfect closure of the ductus arteriosus are acknowledged to stand out among the frequent findings

Diffuse, generalized broadening of the pulmonary artery may have as its cause one of the factors quoted above from Assmann, or any of those conditions associated with even a temporary increase in pulmonary blood pressure, particularly a mitral defect Stasis in the vessels from some other cause, such as pulmonary sclerosis, marked scoliosis, bronchial asthma or emphysema, may also cause it

Local, or at times a general, widening of the arterial branches can also occur as a result of scar-contraction of adjacent tissues, as in tuberculosis or chronic pneumonia (5)

*Age and Sex*—Diffuse broadening of the general pulmonary arterial tree may, of course, occur at any age, as a result of any of the conditions enumerated in which there is a material increase in the back-pressure in the pulmonary circulation Patients with congenital defects of the type mentioned are naturally more likely to exhibit this change at an earlier age than those developing such increased back-pressure from acquired lesions Aneurysms of the first part of the pulmonary artery have been reported in patients of all age groups It has been observed that in young persons aneurysms of the pulmonary artery are found more frequently than are aneurysms of the aorta Some 38 to 50 per cent of the reported cases of aneurysm of this type have been found in persons under thirty years of age (7 and 19) In the majority of patients under thirty years of age, these

aneurysms are coincident with malformations The small aneurysms which are not uncommonly found in pulmonary tuberculous cavities may be found at any age in cases in which such cavitation occurs Males and females show the same frequency of involvement by this type of aneurysm There is a prevalence of the female over the male sex in the proportion of 3 2 in the occurrence of interatrial septal defects, which are a frequent cause of dilatation of the pulmonary artery (20)

*Morphology*—The trunk of the artery has been the site of the aneurysm in some 85 per cent, the pulmonary arterial branches in 15 per cent (4) Usually the aneurysm formations are single but may be multiple as in cavitating tuberculosis or bronchiectasis The shape is ordinarily fusiform but may be sacculated These aneurysms may become very large It has been noted that the media and intima are quickly destroyed by trauma resulting from the causative factors which have already been mentioned The lamellated clot which is usually present may occlude the entire lumen The histologic appearance does not differ greatly from that usually found in aneurysm of the aorta (5) Endarteritis, thrombosis, and atheromatous changes involving the pulmonary arteries, as found in our cases, have often been found (5, 19, and 20) Peck, who has described the syphilitic lesions which have been found in the pulmonary artery, notes that in addition to the type resembling syphilitic aortitis, there is found a more common type with small miliary circumscribed gummas in the media or intima He considers that this more common second type does not produce a true aneurysm Congenital defects of the wall have already been mentioned

The associated changes have already been noted in consideration of the etiologic factors Prominent among these are the congenital malformations, particularly in association with the diffuse generalized broadening of the arterial tree As might logically be expected in these the right ventricle tends to be greatly hypertrophied



and Hochsinger Kranz discusses a diagnosis of aneurysm of this vessel made from clinical and roentgen studies but without autopsy, and considers the differential diagnosis

References bearing upon general widening of the lumen of the pulmonary artery are plentiful but few of these bear upon the roentgen appearance Posselt reviews the general literature up to 1909 Assmann discusses the condition from both clinical and roentgen standpoints Zeidler and Jaffé have described four instances of a lesion similar to the first herein reported, three of these having been observed during life Posselt and Vierordt state that at the autopsy table a moderate dilatation is not a rare finding Roesler reports a case of interatrial septal defect and gives an extensive analysis of the literature, not including, however, the cases of complete absence of the septum

*Etiology*—Assmann has listed the causative factors of increase in the pulmonary bow, the first part of the pulmonary artery as seen on the roentgen film in the anteroposterior projection, as follows

(a) *Acquired*

- 1 Aneurysm of the pulmonary artery
- 2 Perforation of aneurysm of the aorta into the pulmonary artery
- 3 Pulmonary insufficiency resulting from endocarditis
- 4 Deformity from scar-contraction developing in scirrhus of adjacent lung tissues
- 5 Stasis in pulmonary circulation from various causes, most frequently from high-grade valvular incompetency and particularly from mitral stenosis
- 6 Sclerosis of pulmonary artery

(b) *Congenital*

- 1 Solitary, single anomaly  
(Asymmetrical division of truncus arteriosus communis)
- 2 Open ductus Botalli
- 3 Pulmonary stenosis (an exceptional cause)

- 4 Defect of ventricular septum
- 5 Defect of auricular septum
- 6 Transposition of vessels plus a ventricle septum defect
- 7 Tricuspid insufficiency
- 8 Sclerosis of branches of the pulmonary artery
- 9 Stenosis of isthmus aortae below opening of ductus

Prominence of the pulmonary bow is frequently the only roentgenographic sign of a congenital cardiac lesion and is present as a rule in adults having such a lesion It is not usually present in the early months of such a patient's life (8), as it requires a period of time to develop dilatation of the pulmonary artery as a consequence of prolonged exposure to ventricular and aortic back-pressure Except in the cases with asymmetrical division of the truncus arteriosus communis, such abnormal pressure is the common causative factor, resulting usually from (1) communication between pulmonary artery and aorta, (2) communication between the right and left ventricle, or (3) stasis in pulmonary circulation from other causes (2) Our first case had a congenital cyanosis and widening of the pulmonary artery The former has been shown to be due usually to pulmonary stenosis, but such stenosis is only exceptionally associated with widening of the pulmonary artery (2), according to the German teaching Vaquez and Bordet, however, take exactly the opposite view on the latter point (9)

D'Aunoy and von Haam discuss the evidence adduced by various writers which tends to show that local damage to vessel wall and increased blood pressure are important causative factors of aneurysm of the pulmonary artery The former may result from long-continued impingement of a jet of blood upon the wall of the artery immediately distal to a stenosed pulmonary valve or opposite the opening of the ductus arteriosus into the pulmonary They emphasize that sclerosis and syphilis seem to play a less important part in aneurysm here than in the aorta, although the former has been re-

was a marked expansile pulsation evident in the arteries. Pezzi has termed this expansile pulsation "the hulum dance." The appearance of such dilatation may be very confusing if a pneumonic change is also present, as was found in Case 1. The tendency to thrombosis may add infarction to the radiographic picture. If there is increased pulse pressure in the pulmonary circulation, there may be sufficient expansion of the lung structure with each pulse-beat to produce a "dance of the diaphragm" (27), superimposed upon the respiratory movements.

Absence of the aortic knob at the left may occur in great enlargement of the pulmonary artery from any cause, as in marked mitral stenosis or in coarctation of the aorta, and in instances of right-sided aortic arch (20).

The cardiac outline may be of the congenital or mitral type (27). In the instances of congenital origin, it is conditioned in chief part by the great hypertrophy of the right ventricle, although the increase may be mostly to the left of the mid-line.

The differential diagnosis of dilatations of the first part of the pulmonary artery is not difficult in those patients exhibiting it in minor degree, this being a not uncommon finding in conditions of pulmonary circulatory stasis. If the dilatation is marked and there is a lamellated blood clot, differentiation from a mediastinal tumor may be somewhat difficult if the condition is not kept in mind as a possibility. In one instance thus erroneously diagnosed the patient died from hemorrhage after incision of the mass (30). Films made in the right anterior oblique projection are particularly helpful here, in which view an aortic aneurysm or the usual mediastinal tumor is projected more medially. At the hilum, as already mentioned, the vascular dilatation has been mistaken for tuberculous tumor or adenopathy. The appearance of chronic bronchitis is quite different from that of diffuse arterial dilatation. Differentiation from aneurysm of the ductus arteriosus need rarely be made,

as Traub has reported apparently the only case on record.

#### SUMMARY

Two cases of unusual broadening of the pulmonary artery are described, one a diffuse generalized dilatation of the pulmonary artery, and the second an aneurysm of the main stem and right and left branches, each arising as a result of congenital abnormality. Each was studied at autopsy, the diagnosis in Case 1 being made from the radiologic findings during life, and the second only at autopsy notwithstanding numerous consultations. Case 1 presents unusual features in that there was a marked diffuse dilatation of the pulmonary arterial tree of a type which in less marked degree is well known to pathologists but which has been little discussed in roentgen literature, arising on the basis of a congenital cardiac defect, and absence of the interauricular septum. This case was observed over a period of almost five years. Case 2, an aneurysm of the pulmonary artery undiagnosed until autopsy, apparently had its origin in a congenitally weak arterial wall. The literature and radiologic findings are discussed.

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as a result of the stress against which it must necessarily act, also, the left ventricle is small. The auricles may form one large chamber, as noted in our first case. The aorta is small (20). As in our first patient, there tends to be marked infarction of the lung supplied by the involved branch of the pulmonary artery in cases of aneurysm.

*Clinical Symptoms*—Most examiners, we believe, would have been impressed by the asymptomatic cyanosis in Case 1, and would have marvelled at the patient's ability to carry on his work which, as a matter of fact, entailed considerable physical exertion. The case strikingly demonstrates the heart's ability to compensate for both intrinsic and extrinsic defects, and brings out the relationship between asymptomatic cyanosis and congenital heart lesions. During the last two or three years of this patient's life he was at times slightly conscious of shortness of breath, but insisted that it was due to nasal obstruction.

The clinical symptoms of general dilatation of the pulmonary artery are largely those of the causative factor, as indicated in the paragraph on etiology, plus those arising from circulatory stasis in the pulmonary circulation. Assmann has discussed these aspects in some detail, he notes that the physical findings as to heart and blood vessels were not the same in character or degree in various cases. Of his 15 cases personally observed that had increase in the pulmonary bow, all were cases of congenital heart disease, mostly in adults and almost without exception in well developed patients. Cyanosis and finger changes were lacking in all cases with one exception, however, there was in most a slight bluish-red discoloration of the lips and cheeks. As would be expected with increased pressure in the pulmonary circulation, there is clinical and electrocardiographic evidence of right ventricular hypertrophy. Less frequently there are also dilatation and hypertrophy of the left ventricle.

Much the same symptoms may exist in

aneurysm of the pulmonary artery, since this may often arise from the same etiologic factors as are found causative of generalized pulmonary artery increase. Pain in the cardiac area may be very marked, as in our second case, and cough may be an annoying symptom. Dyspnea may be striking (1). The symptoms and clinical findings have been discussed by Kranz and Roesler. There may be a visible protuberance on the chest wall over the area of the pulmonary aneurysm, with or without visible pulsation in the second and third interspaces. A bruit may be evident. Dullness is present in the second and third interspaces at the left of the sternum. A venous stasis may be found in the neck.

*Radiologic Criteria in Diagnosis*—It seems strange that roentgen literature itself has but few references to the radiographic appearance of dilatation of the pulmonary artery and its differential diagnosis. This has resulted in many erroneous diagnoses (20), the most common of which have been tumor and tuberculosis.

Variations from the roentgen normal in this condition, dependent solely upon the dilatation of the pulmonary artery itself, consist of the following: an increase in the pulmonary bow, a small aortic knob (2, 20, and 22), broadening of the hilum shadows, a degree of broadening of the pulmonary arterial tree which will vary according to the etiologic factors and their duration, an enlargement of the cardiac outline. The right anterior oblique position is better adapted to the differentiation of the pulmonary bow increase than is the postero-anterior. Expansile pulsation in this part, as in the hilum portions, may or may not be present, depending upon the presence of lamellated clot. Rosenfeld, who was one of the first to study fluoroscopically an aneurysm of the pulmonary, called attention to the value of the Valsalva test, referring to increase in the pulmonary bow on forced inspiration with the glottis closed. In a generalized dilatation the accentuation of the vascular markings in the pulmonary field may be a striking feature, as in Case 1, in which instance there

# THE USE OF GEIGER-MÜLLER COUNTERS FOR LOCATING RADIUM AND FOR MEASURING GAMMA-RAY INTENSITIES

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THE development of Geiger-Müller counters to a state of good reliability has provided a new order of sensitivity and facility with which weak sources of gamma rays and  $\alpha$ -rays can be detected and measured. Combined with extraordinary

and counters, and are used for measuring weak ultra-violet light, and (3) particle counters, for measurements of alpha, beta, and H particles. Of these forms, there are various mechanical modifications, made to meet the requirements of particu-

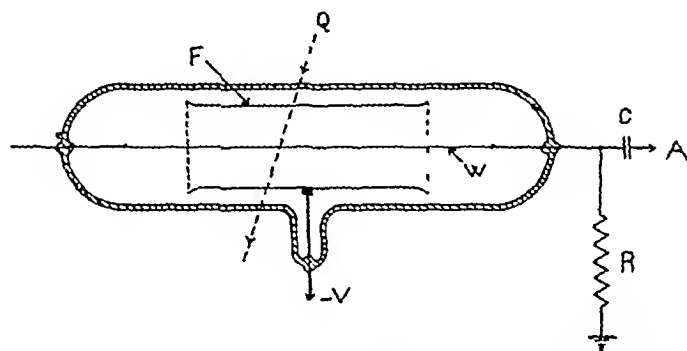


Fig 1 Diagram showing fundamental principles of a Geiger-Müller counter

sensitivity, counters are rugged, stable, simple to operate, and the results of measurements made with them lend themselves to easy interpretation.

Geiger-Müller tube counters are not particularly new instruments. They were invented in 1928 by Professor H. Geiger and W. Müller,<sup>1</sup> as an outgrowth and great improvement of the Geiger counter, or point counter, which had been in use for many years for counting alpha particles. Since their invention, tube counters have been adapted to a large variety of uses in physical laboratories. They have, indeed, become one of the physicist's most powerful tools for measuring weak radiations.

Three general types are now in use: (1) gamma-ray counters suitable for measuring gamma rays,  $\alpha$  rays, and cosmic rays, (2) photoelectric quantum counters, which combine the characteristics of photo-cells

and problems.<sup>2</sup> The present paper deals with counters of the first type, which we have used for locating radium and for making gamma-ray measurements during the last two years.

## 1. CONSTRUCTION AND PRINCIPLE OF OPERATION OF COUNTERS

A counter apparatus consists of the counting tube (counter), an amplifier, usually employing radio tubes, a recording device for registering the number of discharges of the counter, and a suitable source of (negative) high voltage for the counting tube. The negative voltage is usually between 500 and 1,500 volts, depending on the kind of counter used.

The principle of operation of a Geiger-Müller counter (G-M counter) is explained

<sup>1</sup> H. Geiger and W. Müller, *Phys. Zeits.*, 1928, 29, 10, 1929, 30, 489; 1929, 30, 527.

<sup>2</sup> An extensive article describing the construction and use of Geiger-Müller counters is in preparation for the *Review of Scientific Instruments* by one of us (G. L. L.). A preliminary report of some of the work has been given G. L. Locher, *Phys. Rev.*, 1935, 47A, 326.

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size of counter most suitable for a particular purpose must be determined from considerations of the intensities of radiation to be measured, the recovery-time of the counter and electric circuits, and the accuracy desired in the measurements. In general, the most suitable size for any purpose varies inversely with the intensity of radiation to be measured.

Figure 2 is an x-ray photograph of a counter of a type that we find to be very suitable for most gamma-ray measurements. Its cathode is 1.0 cm in diameter and 3.0 cm long. The gas is argon with a little oxygen, at a pressure of 80 cm of mercury.<sup>3</sup>

The gamma-ray efficiency of a counter may be defined as the ratio of the number of its discharges, due to the gamma rays, within any interval, to the number of gamma rays passing through its sensitive region, in the same interval. The approximate efficiency can thus be determined by measuring the counting rate due to gamma rays from a known quantity of radium, at a measured distance from the counter. This procedure is illustrated by the following determination, made with a counter like that shown in Figure 2, using 0.01 mg of radium in a thin-walled container at a distance of 150 cm from the counter.

Spontaneous counting rate due to cosmic rays and stray radio activity of the building 8.42 per min  
Total counting rate with 0.01 mg. Ra at 150 cm

19.65 per min  
Rate due to radium only is thus 11.22 per min

(133 per cent increase in rate over background rate)  
No. gamma rays per sec. from 0.01 mg. Ra<sup>4</sup>

640 (800) (approx.)  
Hence the gamma ray intensity at 150 cm from the source is

2.26 per sq. cm. per sec.,  
or 135.6 per sq. cm. per min. approximately.

So the approximate efficiency of the counter for these gamma rays is  $11.22 / (3 \times 135.6) = 0.028$  or 2.8 per cent.

The efficiency of a counter of the same diameter but five times as long (hence of

five times as great longitudinal cross-sectional area), was determined similarly, for comparison. The spontaneous counting rate of the longer tube is five times that of the short one, the percentage increase in rate, due to radium gamma rays, and the gamma-ray efficiency, were found to be *very nearly the same as those of the short tube*.

The amount of "background," or spontaneous counting rate, of a counter sets a lower limit on the intensity of radiation that can be measured. If the size of the counter is increased, its response to the gamma radiation being measured, and its background rate, increase in very nearly the same proportion, so the "useful sensitivity" remains about the same.

The upper limit of the intensity of radiation that can be measured with any counter is determined by the recovery-times of the counter and amplifying circuits, particularly by the former. The shortest recovery-time so far attained in a G-M counter is about 0.0007 second. Even with such a short recovery-time, it would be impractical to make measurements with gamma radiation whose intensity exceeds 20,000 quanta per second, falling on a counter of 1.0 sq. cm. sensitive area. (This corresponds to about 40.0 mg. of radium at 1.0 meter.) Indeed, it is not usually practical to use radiation of greater intensity than that from about 3 or 4 mg. of radium at one meter, unless very elaborate amplifying and recording apparatus are used. For measurements of stronger radio-active sources, one can, of course, increase the source-to-counter distance, or diminish the sensitive area of the counter exposed to the radiation, by using a heavy shield with a small window.<sup>5</sup> Another very good method is to use a counter of very small size, like that shown in Figure 3. Such counters have two special advantages: their recovery-time is very short (facilitating rapid counting), and the background rate is usually negligibly small. The counter shown has a background rate of 2.0 per

<sup>3</sup> This tube was developed by one of us (G. J. L.) with the assistance of Mr. A. G. Nester for cosmic ray measurements in stratosphere balloon flights. In the last three stratosphere flights 570 such counting tubes have been used.

<sup>4</sup> Rutherford, Chadwick, and Ellis. *Radiations from Radio-active Substances*, p. 503. Cambridge University Press, 1930.

<sup>5</sup> Lead shot in strong containers make convenient demountable shields. About 1.7 cm. of shot is equivalent to 1.0 cm. of solid lead.

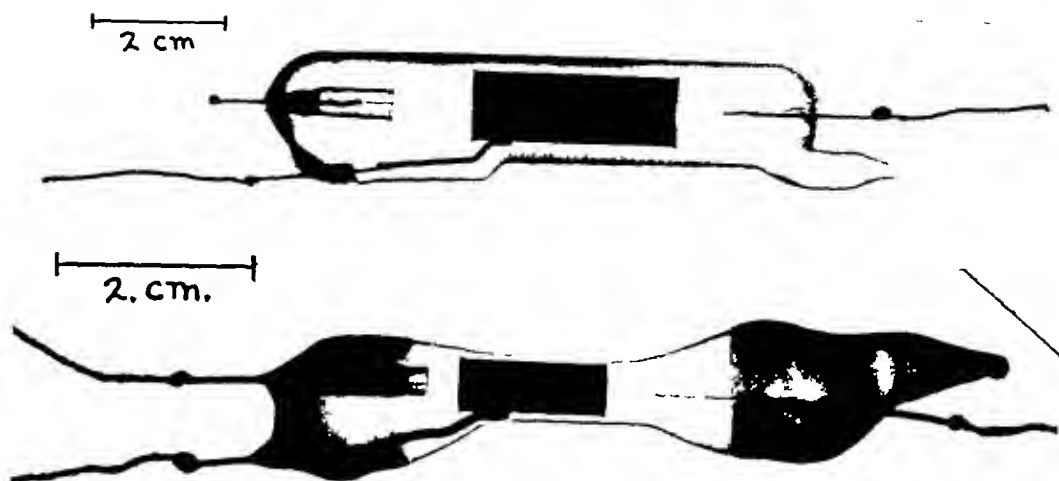


Fig 2 (above) Gamma ray type counter suitable for gamma rays  $\gamma$  rays and corpuscular cosmic rays  
 Fig 3 (below) One type of x ray counter, suitable for gamma ray measurements in cases in which the intensity is relatively high

by reference to Figure 1. A wire,  $W$ , is stretched along the axis of a hollow metal cylinder,  $F$ , enclosed in a glass tube. After suitable treatment of the electrode surfaces, the tube is filled with a suitable gas, usually at about  $1/10$  atmospheric pressure, and sealed off. A negative voltage,  $V$ , is applied to the cylinder-electrode (cathode), the wire (anode) is connected through a small condenser,  $C$ , to a vacuum-tube amplifier,  $A$  (or a string electrometer), and through a high resistance,  $R$ , to ground. The value of  $V$  is adjusted so that it is *nearly* enough to cause a brush discharge between the electrodes. When in this sensitive state, any ray,  $Q$ , passing through the tube and liberating one or more ions in  $F$ , initiates a small gas discharge between the electrodes. This discharge, recorded by  $A$ , is automatically quenched, within a few thousandths of a second, as a result of the lowering of the voltage across the counter by the  $Ri$  drop of potential in  $R$  (where  $i$  is the ion-current conducted through the counter). After this, the counter is again sensitive.

It is evident from the foregoing that the high sensitivity of the counter arises from the fact that it counts the number of individual rays passing through it, whereas other ap-

paratus for measuring ionization require many rays to give detectable ionization. A G-M counter resembles an ionization chamber or electroscope, in that the radiation measured must produce ions within the sensitive region, by photo-electric action or otherwise, but it differs from an ionization chamber or electroscope, in that each ionizing particle liberated in the sensitive volume is automatically subjected to very large amplification *within the counter*. The output of this discharge is adequate for further amplification with a vacuum-tube amplifier. In this way, energy amplifications of many millions are very easily obtained.

## II EFFICIENCY AND SENSITIVITY TO GAMMA RAYS

The sensitivity of any particular counter to gamma rays is determined, especially, by its longitudinal cross-sectional area, other factors include the thickness of the glass tube and metal cylinder, and the kind and pressure of the gas contained in it. However, it is not to be inferred that the useful sensitivity increases with the size of the counter, without limit, even when the intensity of the gamma radiation to be measured is almost infinitesimally small. The

distance should be constant for a given source

TABLE I—RESPONSE OF A SHIELDED COUNTER TO GAMMA RAYS FROM 1 935 MG RADIUM SPONTANEOUS COUNTING RATE 3 47 PER MINUTE

D = counter radium distance, in meters	R = counting rate due to radium no per min R measured	RD
2 0	217 7	870 8
3 0	93 5	841 5
4 0	56 1	897 6
6 0	24 2	871 2
8 0	12 0	769 9
	R extrapolated	Mean
1 0	850	850 2
0 1	85,000	(850)

Calculated rates for other quantities of radium  
at various distances, based on  
 $RD^2/Q = 850 / 1\ 935 = 440$  (approx)

Q = quantity of radium, in milligrams	D = distance in meters	R = computed counting rate
100 0	10 0	440
100 0	1 0	44,000
10 0	10 0	44
10 0	1 0	4 400
10 0	0 1	440 000
1 0	10 0	4 4
1 0	1 0	440
1 0	0 1	44 000
0 0001	0 1	4 4

The constancy of  $RD^2$  shows that the inverse square law is applicable to this apparatus, within the limits of accuracy imposed by variation of the efficiency of the counter, due to filtering of the rays, and small spurious effects arising from the scattering of the rays by air and surrounding objects. This is very convenient, since it makes possible the extrapolation of values of  $R$  corresponding to other values of  $D$ , once the product is known. The rates given in the lower part of Table I are extrapolated for other quantities of radium at various distances, on the basis of  $RD^2 = 850$ , for this counter, kind, and amount of radiation.

Very minute quantities of gamma-ray emitting substances can be measured with a counter apparatus. A convenient measure of the minimum amount of gamma radiation that is "easily detectable," with any counter and configuration, is the intensity of radiation which increases the

counting rate by an amount equal to the background rate. Thus for the shielded counter (Fig 4), about 0 00002 mg of radium, at 5 cm distance, gives an increase equal to the background rate. The un-shielded counter (Fig 2) has a considerably higher sensitivity than the shielded one, because the area exposed is larger, and because the gamma radiation is incident through the side, instead of the end of tube. Only 0 000008 mg of radium, at 5 cm distance, is required to double the background counting rate. This is roughly equivalent to the *natural radium content of  $1/12$  cu ft of ordinary earth*! So it is evident that a counter apparatus is highly suitable for detecting small amounts of radio-active contamination.

Response of the counter shown in Figure 2 to some other weak radio-active sources is as follows: to 1 0 g uranium, sealed in a glass tube, 10 0 cm from the counter, 163 5 per cent increase in rate, to 1 0 g thorium, arranged similarly to the uranium, 54 5 per cent increase in rate, to 100 0 g potassium chloride, sealed in a glass tube and placed against the counter, 8 4 per cent increase in rate (100 0 g KCl corresponds to about one-millionth mg of Ra, in gamma-ray activity).

### III ILLUSTRATIONS OF THE USE OF COUNTERS FOR GAMMA RAYS

It is interesting to note that the shielded counter (Fig 4) was built about two years ago, to meet an emergency. This arose when a 2 0-mg ampoule of  $Ms\ Th_1$  solution was broken, by freezing, in a large lead block that served as a container. With the aid of the counter apparatus, more than 90 per cent of the material was recovered. All vessels, gloves, extracted solutions, and residues were tested for gamma-ray activity at frequent intervals during the extraction processes. The advantages of using a G-M counter for detecting radio-active contamination and for measuring small amounts of gamma radiation became evident at that time.

The second application of this apparatus was for measuring the gamma-ray penetra-



minute, and a gamma-ray efficiency of approximately 2.5 per cent for Ra gamma rays. It was designed for  $\gamma$ -ray measure-

min. The counting rates of this tube, due to 1.935 mg of radium (in Pt needle), placed at various distances from the coun-

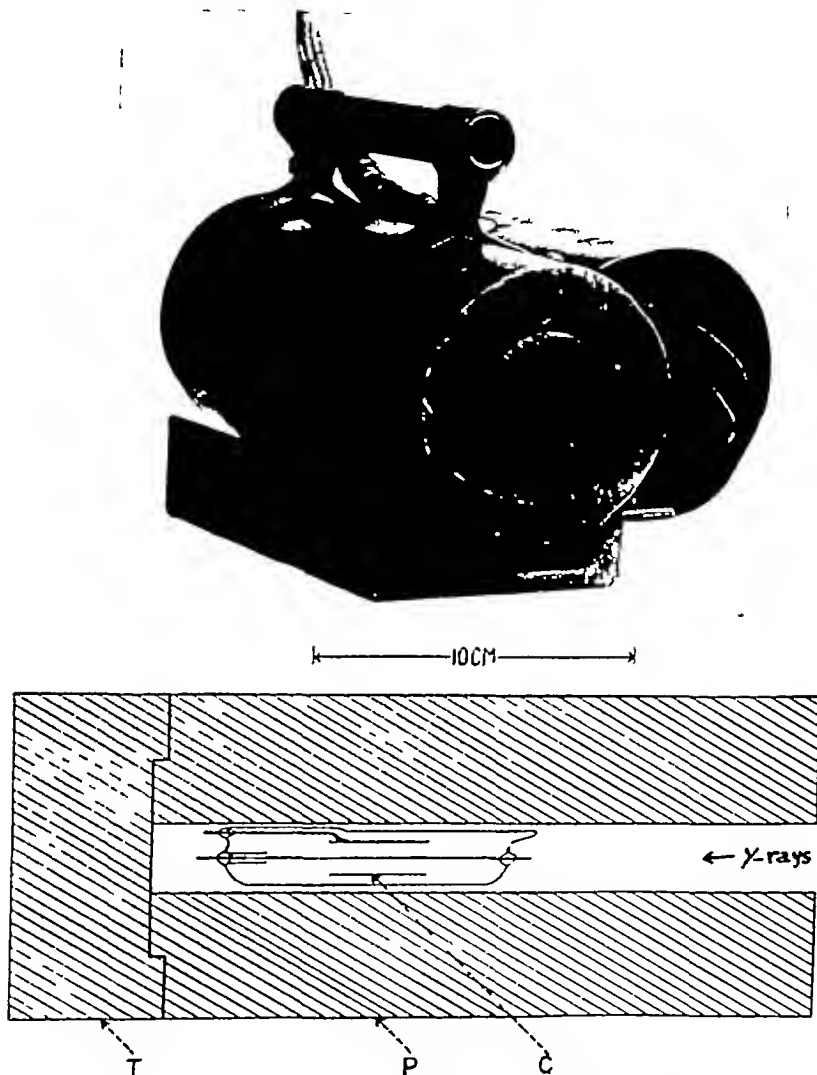


Fig. 4. Shielded counter for directional measurements. *a* (above) view of lead shield and vacuum tube amplifier, *b* (below), cross sectional view, showing position of counting tube.

ments, so the central portion of the glass tube is of very thin Pyrex, to minimize wall absorption.

A *directional counter* for gamma rays can be arranged by shielding the tube with a few centimeters of lead on all sides except that on which the radiation falls. An arrangement of this sort is shown in Figure 4. The shield reduced the background counting rate from about 8 per min. to 3.5 per

min. Since the intensity of radiation from a compact source varies inversely with the square of the distance from the source, the product of the intensity and the distance squared should be constant, if scattering and absorption of the rays are negligible. In the case of a G-M counter, the counting rate is a measure of the intensity, so the product of the counting rate and the square of the

the material sought could be calculated by simple triangulation and the assumption of a value of the absorption coefficient of the

orate equipment, including a source of very constant high potential for the counting tube and a rapid recorder for the counter

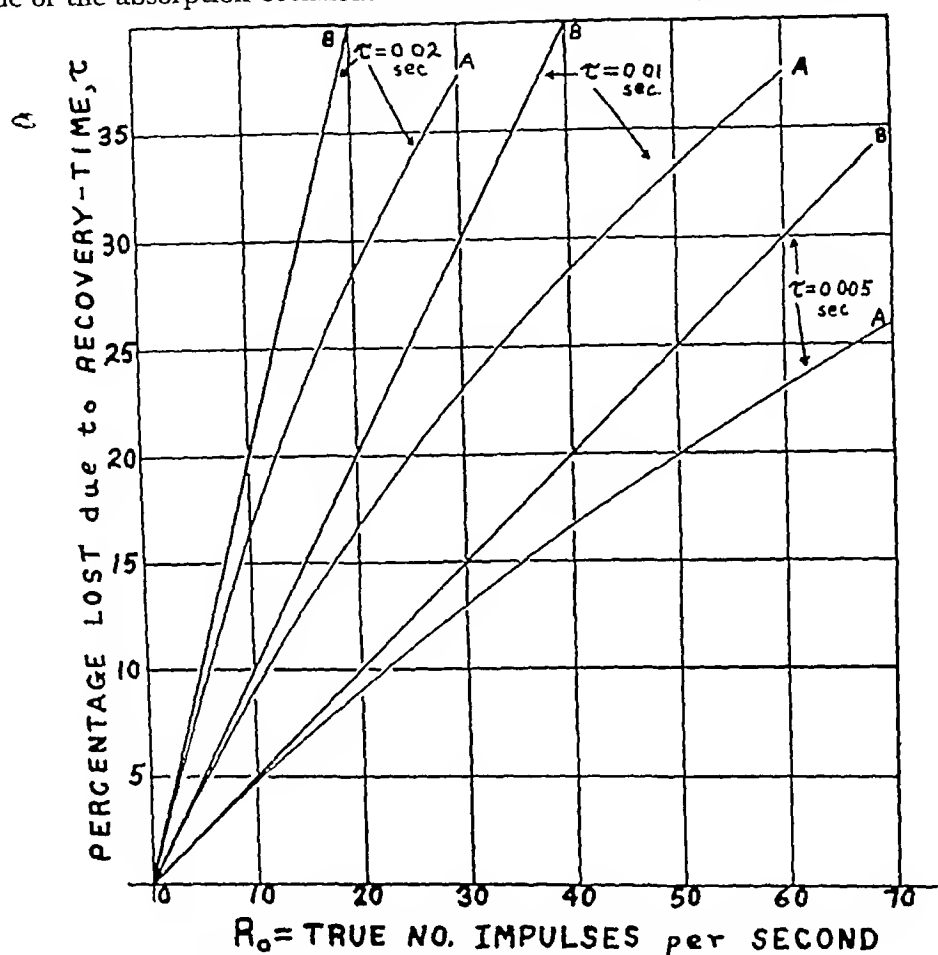


Fig 7 Typical correction curves for resolving time losses based on formulae of Danforth

intervening material for the gamma rays emitted. We have never yet found this procedure necessary.

#### IV. TYPE OF COUNTER APPARATUS

The type of counter set to be used for any purpose depends on several factors: namely, the accuracy required in measurements, the availability of alternating current for the power supply, the permissible size and weight of the apparatus, and the cost of construction. For locating radio-active material a portable apparatus of light weight operating entirely from dry batteries is most suitable. For precise measurements it is desirable to use more elab-

impulses. Such equipment is most conveniently operated from an A.C. lighting circuit.

Figure 5 shows a very light dry-battery-operated portable set in use. The counting tube and vacuum-tube amplifier are contained in a small tubular unit that is attached to the power supply by a flexible cable. The power supply for the amplifier (3 volts and 45 volts) and the high voltage supply (900 volts) come from small dry batteries contained in the carrying case shown. The 900-volt supply is obtained from a 90-volt dry battery, by means of a ten-to-one D.C. 'voltage multiplier'. The use of this multiplier greatly reduces the



Fig 5 Convenient portable counter apparatus employing vacuum tube amplifier and 10 to 1 voltage multiplier in use

successfully taking the counting rates with and without a  $\frac{3}{16}$  inch lead shield before the counter. The coefficient so determined was 0.735 per cm. of lead, as compared with the known value of 0.78 for a mixture of RaB and RaC rays.<sup>6</sup>

The chief advantages of a counter apparatus over electrosopes, for locating lost radio-active material, lie in the great speed of detection and in the high inherent sensitivity of counters. We have used counter apparatus for locating lost radium needles on four occasions. The radium contents of these needles were, respectively, 1.0 mg., 40.0 mg., 10.0 mg., and 1.0 mg. Two were found in sewer traps of hospitals, one was in an ash heap, and one was on a hospital floor. In each case, the location was made in a few minutes, without the necessity of measuring counting rates, since the gamma radiation was immediately detected when the counter was brought into the vicinity of the radium. In one of these cases, a continuous but unsuccessful search for the tube (1.0 mg.) had previously been carried on for some hours, with electrosopes.

In the event that the radio-active material sought is obscured by a large amount of massive material, the procedure would be, of course, to make gamma-ray measurements at numerous points in the vicinity. From these, the approximate position of

\* A counter apparatus is also excellent for detecting x-ray leakage. The efficiency of the counter is of course dependent on the wave length. For x-ray measurements a shielded counter is very desirable, because of scattering from surrounding objects.

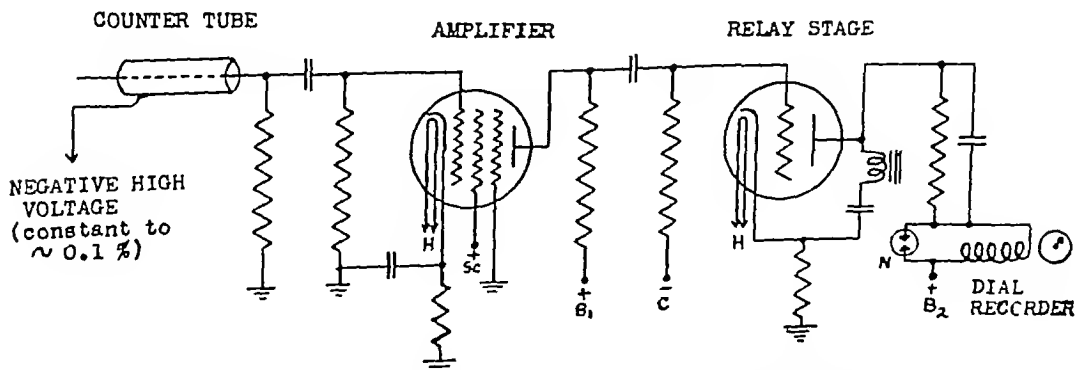


Fig 6 Electric circuit used for precise measurements of gamma ray sources of low and medium intensities.

are convenient for correction, under ordinary conditions. They are

$$(A) R = R_0/(1 + R_0 \tau), \text{ and}$$

$$(B) R = R_0 (1 - R_0 \tau),$$

where  $R$  is the measured counting rate per second,  $R_0$  is the true counting rate per second, and  $\tau$  is the resolving time. Curves representing these relations, for  $\tau = 0.005$  sec,  $0.01$  sec, and  $0.02$  sec, are shown in Figure 7. The value of  $\tau$  can be experimentally determined by applying evenly spaced impulses to the apparatus, through the high potential supply, at increasing speeds, until the apparatus begins to fail to record them.

Illustration of approximate correction of all errors, in an hypothetical case. Background rate of counter,  $4.0$  per min, resolving time of apparatus,  $0.010$  sec, time

of observation,  $12$  min, number of impulses recorded,  $3,600$ . Then the recorded rate,  $R$ , is  $3,600/12 = 300$  per min, or  $5$  per sec. The statistical error  $= \pm 100/\sqrt{3,600} = 1.67$  per cent, or  $\pm 5.0$  per min. Error due to  $\tau$  is between (A)  $4.78$  per cent and (B)  $5.0$  per cent, with a mean value of  $4.9$  per cent, or  $14.6$  per min. Background rate  $4.0$  per min. Hence the corrected rate is  $R_0 = 300.0 - 4.0 + 14.6 \pm 5.0 = 310.6 \pm 5.0$  per min, due to the radiation. The corrections applied are thus,  $10.6/310.6$ , or  $3.4$  per cent of the true rate, in this case.

We are indebted to Herbach and Rademan, Inc., of Philadelphia, for the construction of part of the amplifying and recording equipment used in these experiments, and for the loan of the set shown in Figure 5.

weight of the equipment and makes the cost of the batteries small. The counter discharges are heard as sharp clicks in a telephone head-set worn by the operator.

Figure 6 shows the type of amplifying and recording circuit that we usually employ for precise gamma-ray measurements. This circuit employs a high-gain amplifier and gas-tetrode relay circuit. It is very satisfactory for use with a G-M counter of any type, in instances in which the counting rate does not exceed 1,000 impulses per minute. The number of impulses is registered on a dial recorder. A neon or argon glow lamp,  $N$ , is also provided for visual observation (from a distant point, for example), or for the photographic registration of the individual impulses. For accurate measurements, the negative potential applied to the counter cathode must be held very constant. We accordingly use a Street-Johnson regulated high-voltage source,<sup>7</sup> whose output is constant to better than 1 part in 1,000, for any fluctuations in the A C potential. The entire apparatus is A C operated.<sup>8</sup>

#### V CORRECTION OF COUNTER MEASUREMENTS

The types of error inherent in counter measurements are well known, and corrections for them can be applied with accuracy that is much better than the corrections of usual ionization measurements, unless the counting rates are very high. The chief errors of counter measurements are (1) statistical error, arising from the finite number of impulses recorded, and (2), impulses not recorded because of the "resolving time" of the counting tube or recording apparatus. The "resolving time" of the

apparatus is the time that must elapse between two successive impulses in order that both will be recorded. (It is approx. 0.015 sec. for the recording circuit shown in Figure 6.)

(1) The statistical error is  $\pm 1/\sqrt{N}$ , where  $N$  is the total number of impulses that occur during the observation, or the percentage error is  $100/\sqrt{N}$ . Hence the error is 5 per cent for 400 impulses, 3 per cent for 1,000 impulses, 2 per cent for 2,500 impulses, 1 per cent for 10,000 impulses, etc. All measurements given in this paper have statistical error of approximately 1 per cent.

(2) Correction for the number of impulses that are not recorded, due to the finite resolving time of the apparatus, must be added to the recorded number. The amount of this error is determined by the counting rate and the longest resolving time ( $\tau$  sec.) of the apparatus. If  $1/\tau$  is very large compared with  $R_0$ , the number of impulses per second, the error is negligible. As  $R_0$  approaches  $1/\tau$ , the error increases rapidly, and accurate correction for it becomes more difficult. The reason for this is as follows: with good apparatus and slow counting rates ( $R_0 \tau = 0.001$  to 0.05),  $\tau$  has a constant value, but at high counting speeds,  $\tau$  varies with  $R_0$  in a manner which depends on the particular apparatus. Two simple formulæ, derived by Dr. Danforth,<sup>9</sup> give, respectively, the approximate lower and upper limiting values for the correction. Both assume that  $\tau$  has a definite value, and that the impulses arrive at random times. Formula A assumes that if one or more impulses arrive within time  $\tau$  after a previous one, the latter are not recorded, but that the apparatus is made insensitive by the group only for time  $\tau$ . Formula B assumes that each impulse makes the apparatus insensitive for time  $\tau$ , immediately after its arrival, independently of any other impulses. Neither assumption is wholly correct, especially for high counting speeds, but they

<sup>7</sup> J. C. Street and T. H. Johnson, *Jour. Frank. Inst.* 1932, 214, 155. The first type of voltage control is used. The tube for regulating the voltage is of type 57, which gives better regulation than a 24-A tube. G. L. Locher, *Phys. Rev.*, 1934, 46, 1047.

<sup>8</sup> A semi-portable counter set for gamma rays was demonstrated by one of us (J. L. W.) before the American Roentgen Ray Society at the Atlantic City meeting of the Society, September 1935, during the discussion of a paper by Dr. Robert B. Taft. This set is light in weight but uses A C power, hence is not completely portable.

<sup>9</sup> W. E. Danforth, Bartol Research Foundation of the Franklin Institute unpublished communication.

are convenient for correction, under ordinary conditions. They are

$$(A) R = R_0/(1 + R_0 \tau), \text{ and}$$

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# MANAGEMENT OF CERVICAL METASTATIC EPIDERMOID CARCINOMA<sup>1</sup>

By WRIGHT CLARKSON, M D , and ALLEN BARKER, M D , *Petersburg, Va*

CANCERS about the mouth, pharynx, and larynx rank among the deadliest of neoplasms. This high mortality is not the result of direct extensions of the original lesions, but of lymph node metastases. Many of the primary lesions originating about the head and neck, particularly those beginning in the mucous membranes, are being treated improperly. Lymph drainage areas are often altogether ignored until inoperable metastases have occurred, or inadequate irradiation is given so as to render the growths radioresistant and therefore incurable.

Timidity in the treatment of a malignant neoplasm, whether it be by radiation or by surgery, is almost inexcusable. One must have the courage to be scientifically radical when treating cancer.

The successful management of epidermoid carcinomas of the cervical lymph nodes demands a broad knowledge of the proper application of external and interstitial irradiation, of surgery, of a combination of these methods of treatment, and an adequate knowledge of tumor pathology.

The primary lesion should always be subjected to a thorough microscopic examination, and the method of treatment or combination of methods to be used in each case must be determined by a careful correlation of the microscopic pathology with the history and physical examination.

The dissemination of malignant cells is a danger against which the physician must carefully guard. Since forceful manipulation of a tumor is apt to facilitate this dissemination, care must be taken not to traumatize the lesion during examination. As a precautionary measure against the spread of malignancy, adequate pre-

operative irradiation should always precede the biopsy by about one week.

In removing tissue for examination, it is important to remember that the microscopic appearance may vary widely in various parts of the same neoplasm. Therefore, sections should be taken from various parts of a tumor. Whenever surgically practicable, one should completely remove an original growth that involves one of the upper mucous membranes, taking a wide margin of healthy tissue. This gives ample opportunity for a thorough microscopic study of the neoplasm and is the best method of safeguarding against a local recurrence. The complete removal of an epithelioma of the skin, however, is often undesirable for cosmetic reasons, usually it is not necessary, because the gross appearance and a properly made biopsy will give sufficient information, and the tumor's being more accessible makes it easier completely to destroy the growth by means of irradiation.

Our cases are classified grossly as follows: (1) those having no palpable nodes, (2) those with palpable nodes that are considered operable, (3) those with palpable nodes that are inoperable. Each group requires its own type of therapy, with variations dependent on the individual case and the histologic findings.

Each group is sub-divided into four grades according to Broders' histologic classification, *i e*, Grade I, Grade II, Grade III, and Grade IV. The experience of some observers in the past appears to have indicated that it is not always possible to determine the radiosensitiveness of a tumor by its histologic grading, but the radiosensitiveness of a neoplasm can be so determined accurately, provided one takes into consideration the radiosensitiveness of the tissue or origin and compares the tumor

<sup>1</sup>Read before the Radiological Society of North America at the Twenty-first Annual Meeting in Detroit Dec 2-6 1935



Fig 1 A Grade III cancer of the tongue with growth extending to the midline and small nodes in neck. Roentgen therapy was instituted removal of primary growth radon implantation. There was no return of the cancer at the last examination two years later. Note malignant but fairly radiosensitive cancer tissue shown in photomicrograph (Fig 1 B).

Fig 2 A Grade IV cancer beginning in leukoplakia which had existed ten years metastases to neck and liver. Note cancer developing about the fissure shown in cross section of tongue after removal (Fig 2 B). Microscopic sections show highly radiosensitive type of tissue (Fig 2 C).

Fig 3 A Typical Grade I cancer developing in area of leukoplakia buccal surface. Figure 3-B shows highly radioresistant type of cancer tissue but one that rarely metastasizes. This type may be cured if properly removed. The leukoplakia must be carefully eradicated or cancer may develop again.

only with tumors of the same histologic classification. For instance, with the exception of the melanomas, which strictly speaking should not be placed in this classification, the radiosensitiveness of epidermoid carcinomas increases in direct proportion to the amount of anaplasia, and we believe this rule will hold true of all neoplasms when considered separately within their own histologic classification.

#### GROUP I

In considering the first major group into which our cases are divided, we find some controversy, that is, radiologists as a rule advocate external irradiation while many surgeons advise complete block dissection of the neck. There is however evidence that lymph nodes act as a barrier to the spread of cancer and therefore it is wise to preserve them when possible. Prophylaxis

by proper external irradiation is as successful as surgical prophylaxis. Widmann (1) reports a group of patients in whom only 17 per cent of those receiving proper external therapy developed cervical metastases while 51 per cent of the non-irradiated cases developed uncontrollable metastases. These statistics compare favorably with those of the most experienced surgeons.

The patients in this group should be given the benefit of thorough external irradiation. Each side of the neck, including the base of the brain and the clavicles, should receive a total of from 2,000 to 3,500 roentgens, the exact amount depending upon the size of the primary growth, its duration, the amount of invasion of the surrounding tissues, the radiosensitiveness of the lesion, the patient's physical condition and the reaction of the individual to the irradiation. The treatment should be



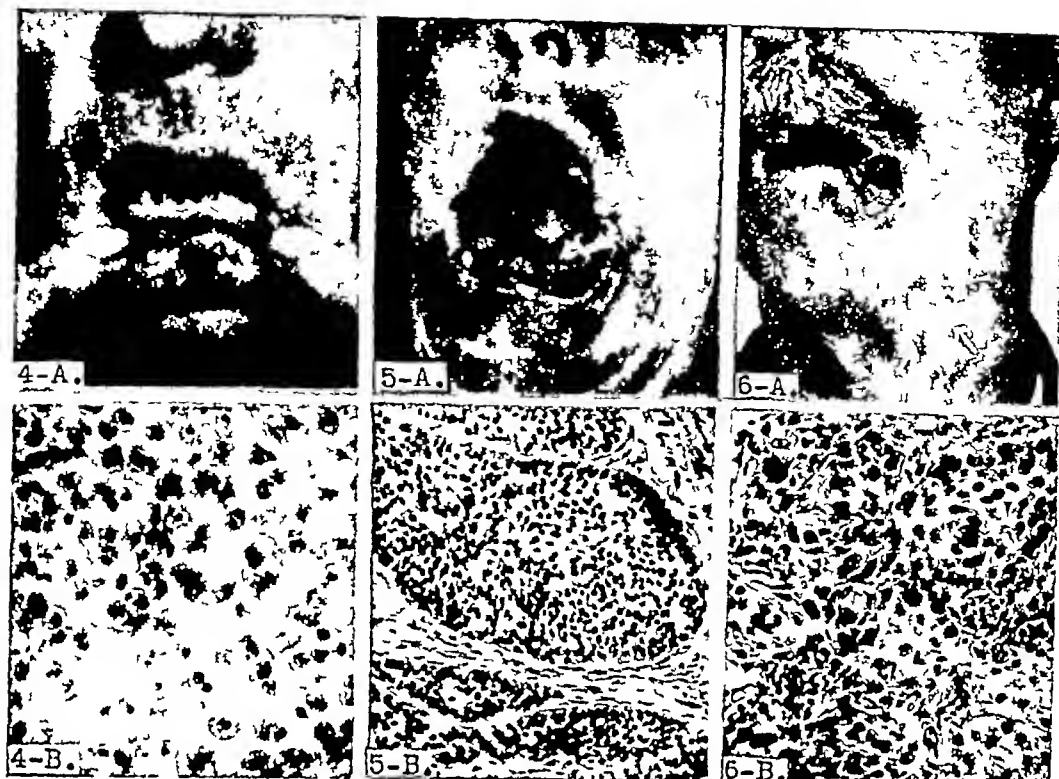


Fig 4 A A rather harmless looking little lesion with no nodes but photomicrograph (Fig 4-B) shows Grade IV carcinoma. These lesions cannot be recognized without microscopic examination. They are fatal unless diagnosis is made and growth and lymph drainage areas are intensely irradiated at early stage. This patient refused irradiation and died soon after extensive operation by an eminent surgeon.

Fig 5 A Horrible looking cancer of the lower lip, Grade III, with metastatic nodes. Note photomicrograph. Figure 5 B Patient well to-day, 8 years after photograph was taken. Treatment: extensive external irradiation and removal of primary lesion with endotherm.

Fig 6 A Cancer of lip, Grade II, see Figure 6 B. The mass below the jaw which was firmly fixed to the bone was not sensitive and was slowly but progressively enlarging. Massive doses of roentgen ray were given. no other treatment. Well to day, 9 years later.

given in daily doses over a period of about four weeks. If metastases do not appear later, no further treatment is necessary. However, if after proper irradiation metastatic nodes do appear, they should be removed surgically, if possible, for further irradiation will not control them.

#### GROUP II

The successful management of the second group is dependent upon a thorough knowledge of tumor pathology, upon the radiologist's ability to administer scientific external and interstitial irradiation, and upon the criteria for operability.

Operability is often quite difficult to determine, but as the experience of the radiologist increases, more definite and accurate

criteria are established, with the result that fewer cases are placed in the surgical group. Quick's (2) criteria for operability are as follows: "Surgical dissection of the neck, when done, is unilateral, but the most radical possible. Dissection is limited to fully differentiated epidermoid carcinoma, palpable involvement unilateral, capsule of the node or nodes presumably intact in patients presenting good physical condition, and in whom the primary growth is either controlled, or gives promise of complete controllability."

Average statistics of radical neck dissections show a high mortality from recurrences, and our records show a survival of few cases so treated. The procedure is, therefore, limited to a few carefully selected

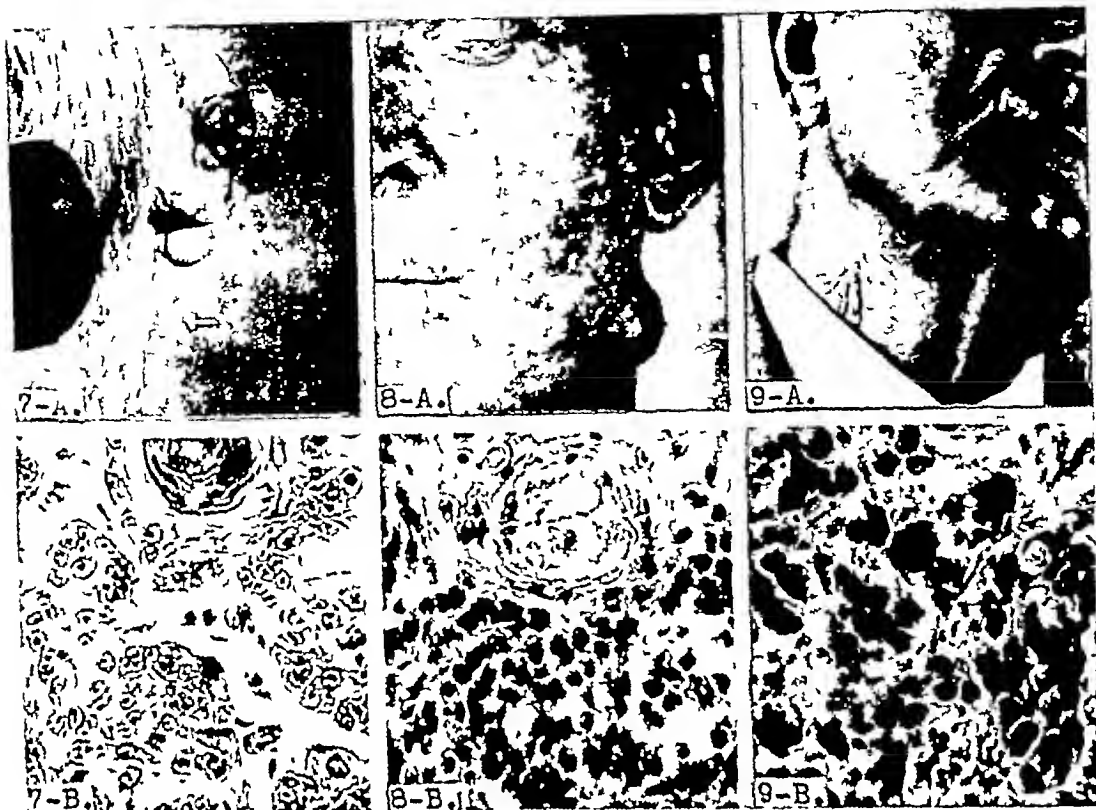


Fig 7 A Cancer of pinna cervical metastases, treated by roentgen therapy and implantation of nodes See photomicrograph Figure 7 B, Grade II Patient well 3 years

Fig 8 A Metastatic cancer following electric coagulation of skin lesion in a physician's office Photomicrograph (Fig 8 B) taken from node Grade III Intensive external irradiation was given, only the isolated mass shown in photograph was removed Patient well 5 years

Fig 9 A Photograph showing skin in good condition, patient clinically well three and one-half years after 3000 r had been given to each side of the neck and 9000 me-hr interstitial irradiation for cancer of pharynx Grade IV Note extremely anaplastic cells removed from metastatic lymph nodes, photomicrograph Figure 9 B

cases The method of choice is intensive external irradiation as advocated in the first group of cases, followed, as soon as the skin reaction subsides, by surgical removal of isolated palpable nodes and interstitial irradiation of any palpable masses of nodes that may remain Electrosurgery is preferred for the removal of the nodes (Fig 8)

At this time it is important to emphasize the fact that proper interstitial irradiation usually requires surgical exposure as it is often impossible accurately to implant through the skin a node or nodes with radium element or radium emanation

Grade I neoplasms (Fig 3) are slow to metastasize but once metastases have occurred no combination of irradiation is likely to produce a cure In this type of

malignancy, with multiple intact nodes, radical surgery following thorough external irradiation offers the best hope of eradicating the growth If only a single palpable node is present, it is often wise to remove only this node In either case, all areas from which nodes are removed should be implanted with radium emanation, the dose of irradiation being limited only by normal tissue tolerance

The Grade II metastases are also relatively radioresistant, and they may be treated in somewhat the same manner as the Grade I tumors, although these metastases if small, may yield completely to proper external and interstitial irradiation (Figs 6 and 7) Large nodes remaining after intensive external irradiation should

be removed by means of an endotherm, radical neck dissections are seldom indicated in neoplasms of this grade

The relatively anaplastic Grade III metastases should be treated with a combination of external and interstitial irradiation. In most of these cases surgical removal of metastases is neither wise nor necessary. After the skin reaction from thorough external irradiation has subsided, any remaining palpable nodes should be implanted with radium emanation (Figs 1 and 5)

The radiosensitive Grade IV metastases may often be trusted to thorough external irradiation alone, but even in these cases implantation therapy is a wise precaution and should always supplement external irradiation when the metastatic nodes are large (Fig 9)

Recurrences often occur even though proper external and interstitial irradiation has been given, and these nodes, if still operable, should be subjected to radical dissection because additional irradiation is practically useless

#### GROUP III

Inoperable cervical nodes, irrespective of their grade, usually present a problem for irradiation only, however, an inoperable case may occasionally be made operable by proper irradiation. External and interstitial irradiation should be given in massive doses. Many of these patients can be made comfortable for a few months or years and occasionally a cure may result when the metastases are highly radiosensitive

One of the most perplexing problems confronting radiologists at this time is, what disposition should be made of the many inoperable cases in which the tumors have previously been rendered radioresistant by improper and inadequate irradiation? It may seem wrong to refuse to further irradiate some of these cases. Certainly, each one of them should be carefully analyzed and treated if there remains the slightest hope of a cure or substantial improvement, but most of them cannot be

materially benefited by further irradiation and there is considerable doubt in our minds as to the advisability of attempting further local treatment in these cases

During the past few years we have irradiated the gonads and pituitary glands of these hopeless patients. This appears to retard the growth to some extent, but our experience so far has not been sufficient to justify definite conclusions

#### MELANOMAS

The metastases resulting from melanomas comprise a radioresistant group of tumors in which, immediately following proper pre-operative irradiation, a radical operation should always be performed, provided all of the known metastases can be removed with a reasonable degree of safety

#### LETHAL DOSE AND TISSUE TOLERANCE

Scientific irradiation therapy requires an accurate knowledge of the lethal dose of different types of irradiation for various types of neoplasms, as well as a knowledge of the tolerance of normal tissues to the same irradiation. The fractional dose technic has opened new avenues of approach to neoplastic diseases with roentgen irradiation. By this method it is possible to deliver from three to five skin erythema doses to the deep cervical glands and still permit a rapid recovery of the normal tissue. The time factor is extremely important, the total dose should be divided into equal daily doses administered over a period of four weeks. Coutard's method (3) of applying high voltage roentgen irradiation with low intensity apparently gives better results than the more recent high intensity technics

Irrespective of the technic of external irradiation used, it is impossible to deliver to deep cervical glands the seven to ten skin erythema doses which Martin, Quimby, and Pack (4) have shown to be necessary for the complete destruction of an adult carcinoma. Therefore, it is imperative to supplement external irradiation with interstitial therapy, since a large percentage of metastases originate from a low

grade squamous-cell carcinoma. Reference to standard tables of dosage measurements indicates that it requires 10,000 millicurie-hours to deliver 10 skin erythema doses to a tumor mass 5 cm. in diameter, and 6 skin erythema doses to a mass 7 cm. in diameter. Such a dose will require approximately 80 millicuries of radium emanation to be left in the tissues until completely destroyed. With the aid of such figures, the amount of emanation necessary to sterilize a metastatic mass may be determined accurately. The emanation should be divided into implants of not more than 3 mc. each, and they must be spaced carefully so as to distribute the irradiation evenly. Although roentgen irradiation will materially reduce the necessary dose of interstitial irradiation, it is always wise to apply dosage up to the limits of tissue tolerance.

#### COMPLICATIONS AND SUPPORTIVE TREATMENT

Among the more serious complications arising in the treatment of malignancy is the presence of infection. In these cases interstitial irradiation is contra-indicated until the infection has subsided, and since the strings attached to removable implants assist drainage, they are usually preferable to permanent radon seeds.

Small daily doses of external irradiation are more beneficial than massive doses in treating infections, and, therefore, it is well not to exceed a daily dose of 100 r for about ten days. Accumulations of pus should always be evacuated by means of an endotherm as soon as they become localized and fluctuant.

By making a careful analysis of the general physical condition and by keeping a close watch for such co-existing diseases as syphilis, diabetes, and cardiovascular or vascular disease, one may frequently save a cancer patient who would otherwise succumb. Likewise much may be accomplished by giving general supportive treatment to these patients when they show signs of nutrition. For instance, most patients with advanced cancer have a deficiency of hydrochloric acid in the stomach,

and correcting this by intravenous injections or by giving the acid by mouth often proves beneficial.

The administration of vitamin concentrates will improve the general condition of the patient, and they should be given whenever specifically indicated, but it is possible for these concentrates to stimulate cancer growth also, and, therefore, their proper place in cancer therapy must await further experimentation. The same thing may be said about the administration of insulin. Its proper administration in cases complicated by diabetes is usually imperative in order to preserve the integrity of the skin that is being irradiated, and in non-diabetics it will increase appetite and thus prove temporarily beneficial to the patient, but no one can be certain at the present state of our knowledge about cancer that malignant metastases are not likewise stimulated. Therefore, for the present it may be well to confine its use to diabetics and to non-diabetics in a state of extreme inanition. In the latter case everything possible should be done to support the patient rather than direct all of our attention to the cure of the neoplasm.

#### SUMMARY

(1) The present high mortality rate from carcinomas of the upper mucous membranes is largely the result of a lack of proper treatment of the areas of lymph drainage by many physicians who attempt to treat the primary lesions.

(2) Pre-operative irradiation should always precede biopsy and all other forceful manipulations of the primary lesion.

(3) The possession of a thorough knowledge of the various methods of treatment, of adequate knowledge of tumor pathology, and of sufficient courage to be scientifically radical are absolutely essential when treating cancer. Careful attention must be paid to the lethal dose of irradiation for the various types of neoplasms and whenever indicated the irradiation must be carried to the limits of tissue tolerance.

(4) The radiosensitivity of an epidermoid carcinoma increases in direct propor-

tion to the amount of anaplasia, and this rule probably holds true of all neoplasms when considered separately within their own histologic classification. Therefore, sections should be taken from various parts of the primary growth to insure accurate grading and the direction of treatment accordingly.

(5) Prophylaxis is left to external irradiation alone. All cases with metastatic nodes are treated principally by a combination of external and interstitial irradiation. The operable nodes that may then remain are removed by means of an endotherm. Radical surgery is resorted to only in operable cases of melanomas and Grade I carcinomas with extensive metastases.

(6) In cases of infection, small daily doses (100 r) of external irradiation should be given first for about ten days, pus collections should be evacuated with an endotherm and in cases in which implantation therapy is used, removable seeds are advised because the strings facilitate drainage.

(7) Insulin and vitamin concentrates will improve the appetite and general con-

dition of cancer patients, but no one can be certain at the present state of our knowledge that malignant cells are not likewise stimulated. Therefore, for the present it may be well to confine their use to diabetics and to non-diabetics in a state of extreme inanition.

In closing, we wish to express our appreciation to Dr. A. C. Broders for his assistance in grading the neoplasms we are reporting here as illustrations, and to Dr. J. S. Horsley, Jr., for his assistance in removing the nodes shown in Figure 8.

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# THE TREATMENT OF BENIGN UTERINE HEMORRHAGE BY IRRADIATION<sup>1</sup>

By JAMES J. QUINEY, M.D., *Easton, Pa.*

It is not my intention to advance any new theories as to cause or methods of treatment but to review facts which are already well known.

It has been stated by Anspach in the first edition of his work that, "almost every form of benign uterine hemorrhage is favorably influenced by radium treatment." So far as my own personal experience is concerned, I have found the use of external irradiation by means of the roentgen ray extremely satisfactory and I now rarely use radium, thereby avoiding the surgical procedure necessary for its intra-uterine application.

The causes of benign uterine hemorrhage may be classified as follows:

- 1 Myopathic uterine changes,
- 2 Glandular hyperplasia of the endometrium,
- 3 Functional disturbances of the ovary or ductless glands,
- 4 General diseases of the heart, kidney, liver, circulatory organs, etc.

The hemorrhages may threaten life by producing anemia or they may be merely a constant source of annoyance.

Irradiation is undoubtedly the treatment of choice in cases of menorrhagia of the menopause associated with fibromyoma. It yields extremely satisfactory results in cases in which the fibromyoma does not exceed in size a four-months pregnancy and in cases of a fibrous uterus in which the possibility of malignancy has been eliminated by the history or by a curettage (1).

In cases of hemorrhage at or near the menopause it is considered proper by many radiotherapists to irradiate as for malignancy. Every attempt should be made, however, to eliminate malignancy by a binomial and visual examination of

the cervix, as advocated by Dr. J. Mason Hundley, of Baltimore, making use of Schiller's iodine test and by making a microscopic examination of the scrapings obtained by a careful curettage. I am more and more impressed with the necessity of this procedure. By observing these rules in all cases, disappointment to the patient and embarrassment to the therapist can be avoided.

In treating uterine fibromyoma it is immaterial as to whether the tumor is submucous, interstitial, or subserous (2). A pedunculated fibromyoma is not considered suitable for treatment. A degenerating or strangulated fibromyoma should be removed by surgical procedure unless there are very definite contraindications to an operative procedure. Fibromyomas of such dimensions that they extend above the umbilicus, or those causing pressure effects should also be removed surgically.

Pelvic infections are a definite contraindication to the use of radium but this statement does not so strictly apply to the use of the roentgen ray.

Neill, of Baltimore, is responsible for the statement that 75 per cent of all uterine fibroids are amenable to irradiation therapy, probably meaning radium. This number is increased when the roentgen ray is the therapeutic agent used. Neill also states in the same article that the response to irradiation in cases of uterine fibroid is very rapid, in some instances showing a great reduction within a few weeks, in other instances, disappearance occurs six months to a year after the bleeding stops and 80 per cent of the smaller and 50 per cent of the larger tumors disappear completely.

On Sept. 27, 1919, Dr. A. Beclère, of Paris, presented a contribution to the Association of French-speaking Gynecolo-

<sup>1</sup> Read before the Pennsylvania Radiological Society, June 1, 1919.

gists and Obstetricians at Brussels In this report he presented the statistics of 400 cases of uterine fibromyoma treated by x-ray in his own private practice from 1908

The greatest number of cases occurred between 45 and 49 years of age, the fewest between 55 and 56 years of age

Of the 400 cases, 15.5 per cent were intrapelvic and 84.5 per cent consisted of fibromyomas with abdominal projections—above the symphysis from 1 to 4 centimeters in 38 patients, and from 25 to 30 centimeters in 9 patients

In the great majority of the patients the predominating symptoms consisted of metrorrhagia, more or less copious, prolonged and regular in appearance

Treatments consisted of weekly applications of moderate dosage in preference to a monthly intensive dosage Each weekly treatment consisted of two successive exposures, one to the right and one to the left of the median line of the abdomen just above the horizontal ramus of the pubes Occasionally, because of retro-displacements or when the fibromyoma occupied the concavity of the sacrum, a third exposure was directed toward the sacral region If the dimensions of the tumor required it, six ports were used Each exposure was localized on a circular surface, 10 centimeters in diameter, by means of a cylinder of lead glass Beneath this cylinder of lead glass was placed a block of wood and, by means of compression, the surface was flattened and the distance between skin and ovary lessened The distance used was from 7.2 to 8.8 inches and one milliamperere of current was allowed to pass for from 10 to 15 minutes

In 60 per cent of the 400 patients the course of treatment extended over a period of from two and one-half to three months Twelve to 14 weekly treatments were given In only four cases did radiotherapy fail, and, so Beclère states in his article, with the more modern technic used at the time of writing his paper, even these four cases would have been cured The

metrorrhagia ceased and there resulted a suppression of the menstrual function

The onset of hot flashes incident to the menopause was the signal for cessation of the treatment The menses would occasionally reappear after several months, whereupon a small number of abdominal exposures became necessary The size of the tumor was reduced from one to two centimeters in 12 patients and 16 centimeters in one patient A corresponding reduction also took place in the transverse diameter of the uterus

Since 1919, at the time these facts were presented, great improvements in equipment have been made, such as the enormous increase in the output of transformers, the construction of x-ray tubes in such a manner that the output of roentgen rays can be more readily regulated, the acquirement of a better knowledge of filtration, and the establishment of the r unit These improvements have added materially in the administration of adequate dosage

To-day there are several methods of treating these cases efficiently with the roentgen ray A great change has occurred since 1919, when Beclère presented his remarkable article

Henry Schmitz (3), in a recent article, states "The roentgen dose for the production of permanent amenorrhea is about 400 r with back-scattering measured in the mid-pelvis and attained through two fields, one suprapubic and one sacral The kilovoltage should be 200 and the filter 0.5 to 0.75 mm Cu plus 1.0 mm Al" He warns of the necessity of standardization of the output of transformer and tube with r unit meters to attain the expected result

With the above factors but little time is required to administer the 400 r unit (50 per cent) dose in the mid-pelvis, it is well, however, to divide the dose and give it over a period of time, making up the total loss in r units

Schmitz also states "The good end-results of irradiation treatment in the functional uterine hemorrhages was 316 in a total of 322, or 98.14 per cent, and the mortality was 0.66 per cent The

good end-results in bleeding uterine myomas was 103 in a total of 109 cases, or 94.5 per cent, and the mortality was 1.0 per cent."

For some time it has been our custom to treat through four  $15 \times 15$  cm areas, two anteriorly and two posteriorly, directing the central beam to the uterus and ovaries. The method employed is that advocated by Weatherwax using 200 kv, 5 ma, 0.5 mm Cu plus 1.0 mm Al, and using 650 r in the center of the pelvis.

At each sitting, 200 r is given over each area, making up the loss of each interval, until the desired number of r units have been delivered to the uterus and ovaries.

In treating all types of benign uterine hemorrhage it is well to begin the series soon after complete recovery from the menstrual period. By so doing menstruation is less likely to recur as often after the period as would be the case if the patient were treated immediately before the onset of a period. It makes little difference, however, at what time during the menstrual cycle treatment is begun.

Though it is common for there to be no recurrence of the period, it is also common for the first and second periods to occur, the third period may consist only of a watery blood-tinged discharge after which cessation is usually complete.

In establishing a premature menopause in the manner described it should be stated that the patient does not escape the symptoms which usually accompany this change. It is claimed, however, that the symptoms do not extend over so long a period of time when the menopause is brought on by radiotherapy as when it occurs naturally.

Radiotherapy in the treatment of uterine

myoma had its origin in France in 1904. It was not long, however, before the German radiotherapists had adopted a similar treatment by means of the x-ray, however, they advocated much heavier dosage. Controversy soon arose as to the method of action of the rays in curing uterine myoma and its accompanying hemorrhage.

The Germans maintained that the graffian follicles in the ovaries were destroyed and that without maturation of the graffian follicles the ovaries became functionless organs. It was known for some time that an uterine myoma grew smaller and at times disappeared after the menopause and, therefore, the destruction of the ovary, which resulted in the cessation of menstruation, was the cause of the good results obtained by radiotherapy.

The French were equally insistent that the mode of action of the rays was due to a direct effect on the tumor, resulting in a disappearance of its muscular structure.

So far as I am aware, the good results are held to be due to the effect on both the ovaries and the tumor.

Hyperplastic glandular lesions of the endometrium are frequently relieved by curettage, bed rest, and medication. When hemorrhage from the uterus is due to dysfunction of the ductless glands, glandular therapy is indicated.

The response to irradiation in all cases of benign uterine hemorrhage, however, is usually prompt and permanent.

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# PLANOGRAPHY, LOCALIZATION, AND MENSURATION "STANDARD DEPTH CURVES"

By JULIUS KAUFMAN, M D , Brooklyn, N Y

FOR simplicity's sake this treatise has been divided into five sections, as follows

- I Technical Data
- II Technical Data Applied to Localization
- III Technical Data Applied to Planeography
- IV Clinical Considerations
- V Summary

## I TECHNICAL DATA

A roentgenogram of an object may be considered a composite picture of in-

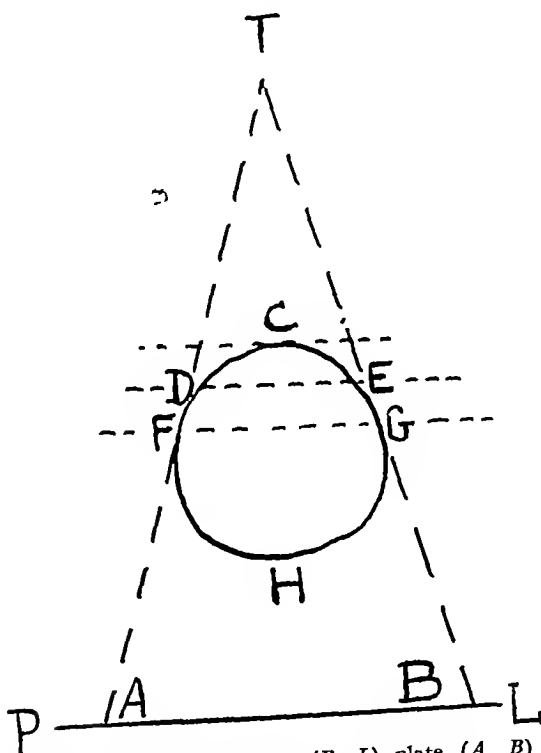
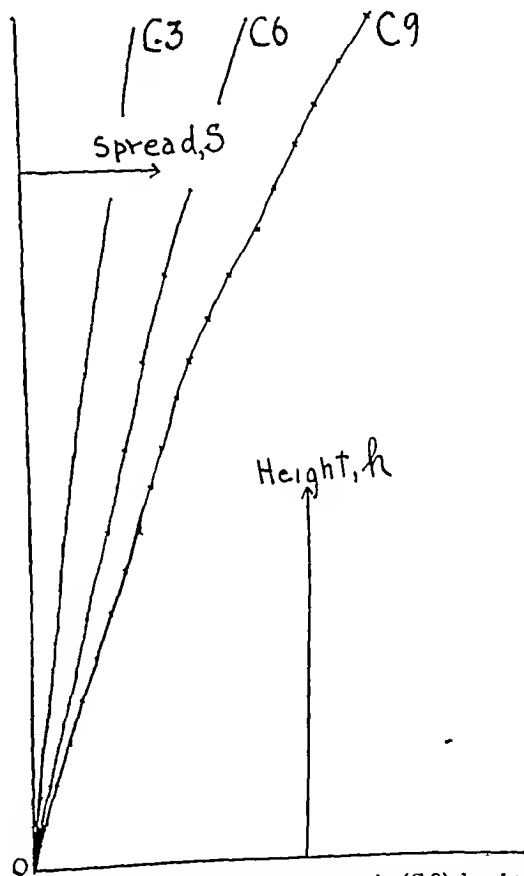


Fig 1 (T), target position, (P L) plate, (A B) roentgenogram, (C-D-E-F-G-H), object

numerable roentgenograms of parallel, juxtaposed tissue slices of which the object is composed. Thus (Fig 1), the roentgenogram, A B, really represents a roent-

genogram of slice, C-D-E, superimposed upon a roentgenogram of slice, D-E-F-G, etc. If the thickness of the slices be re-



Graph I "Standard Depth Curves" (C3) height,  $H$ , of target above plate  $\approx 32$  inches spread of target positions  $\approx 3$  inches, (C6) height  $H$  of target  $\approx 32$  inches, spread of target  $\approx 6$  inches (C9) height  $H \approx 32$  inches, spread of target  $\approx 9$  inches

duced to an infinitesimal quantity, each slice may be considered a plane for all practical purposes. A roentgenogram may be considered, therefore, the integration of serial planeograms. Planeography refers to the differentiation of individual planes.

We have evolved a method by which it is

possible to demonstrate any plane in space, parallel to the plane of the plate, from two (or more) roentgenograms properly taken

In Figure 2

(a)  $C-D-E-F$  represents the plane of the plate in the horizontal position,

(b)  $T1$  and  $T2$  represent two target positions, height,  $H$ , above the plate level,

(c)  $C-D-G-H$  represents a vertical plane, passed through  $T1$ ,  $T2$  intersecting  $C-D-E-F$  in  $X-Y$

(d)  $VT2$  and  $VT1$  represent the vertical projections of  $T2$  and  $T1$ , respectively

(e)  $A$  and  $B$  represent any two points in a plane parallel to the plane of the plate, height,  $h$ , above the plate level

Demonstration

(1) Pass planes  $T2-A-B$  and  $T1-A-B$ . They intersect  $C-D-E-F$  in  $T2A$ ,  $T2B$  and  $T1A$ ,  $T1B$ , respectively

(2)  $T2A$ ,  $T2B$  and  $T1A$ ,  $T1B$

$T2A$  and  $T1B$ ,  $T2B$  are parallel to  $VT2$ ,  $VT1$

(b) The spread,  $S$ , that is, the distance separating the images of a given point, in a

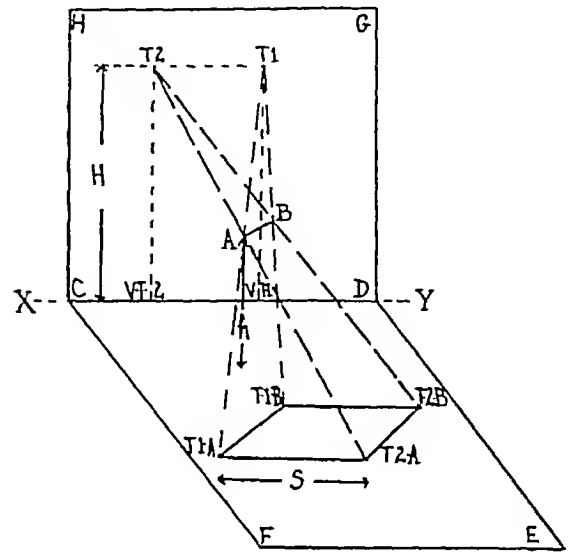


Fig 2

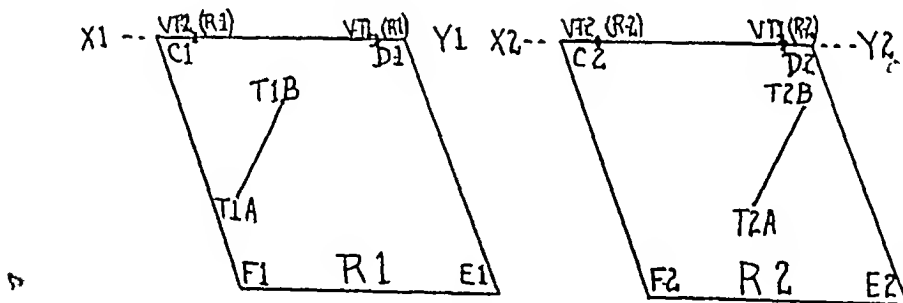


Fig 3

are both parallel to  $A-B$  and they are, therefore, parallel to each other

(3)  $T1A$ ,  $T2A$  and  $T1B$ ,  $T2B$  are both parallel to  $VT2$ ,  $VT1$  and they are, therefore, parallel to each other, and also to  $T1A$ ,  $T1B$

From the demonstration above the following inferences follow

(a) The images of any, and of all, points in a given plane parallel to the plane of the plate, exposed in two target positions at the same height above the plate level move along lines parallel to a line joining the vertical projections of the target positions. In Figure 2  $F1$

given plane in space, is a fixed determinable quantity ( $T1A$ ,  $T2A$  in Figure 2). Spread,  $S$ , is equal for all points in that plane ( $T1A$ ,  $T2A$  is equal to  $T1B$ ,  $T2B$ )

(c) If the exposures are upon two plates (see Figure 3),  $R1$  and  $R2$  representing the roentgenograms in  $T1$  and  $T2$  positions, then  $R2$  may be made to superimpose  $R1$  exactly (see Figure 4) by superimposing  $X2$  upon  $X1$  so that  $VT2(R2)$  becomes equal to spread,  $S$ . This superimposition represents the planeogram of the plane in which  $A-B$  lies (that is for a plane, height,

$h$ , above the plate level) It can readily be seen that for any other plane in space, spread,  $S$ , will vary, depending on its height above the plate level Since spread,

equal to  $H$ , the height of the target above the plate level

Suppose we wish to find spread  $S$ , for a point  $O$ , height  $h$ , above plate level

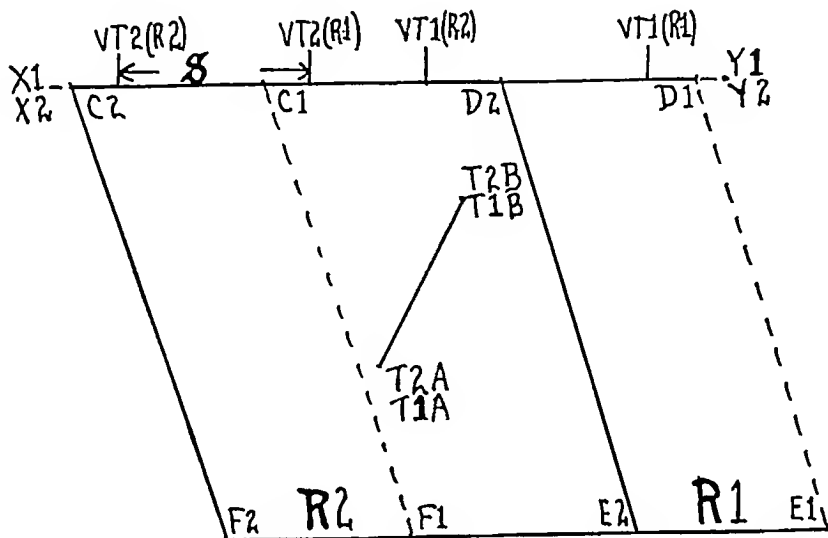


Fig 4

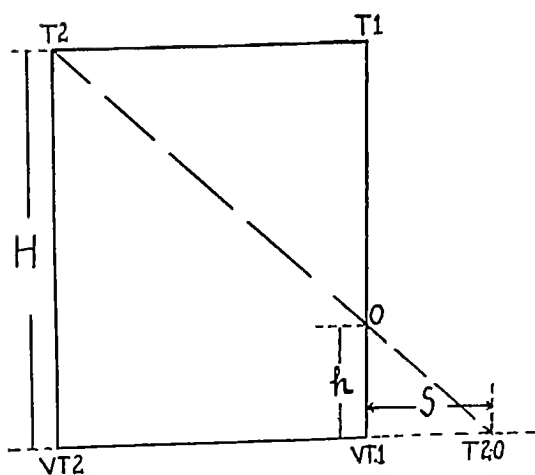


Fig 5

$S$ , is the correction factor used in depicting the planeogram, it becomes necessary to determine spread,  $S$ , in terms of height level

The relationship sought may be easily obtained by the following construction (see Figure 5)

Construct (Fig 5) rectangle  $T2-T1-VT1-VT2$ , so that  $T2-T1$  is equal to the target shift, and so that  $T2-VT2$  is

Proceed as follows

- (1)  $VT1-O$  is made equal to  $h$ ,
- (2)  $T2-O-T2O$  is drawn,
- (3)  $VT1-T2O$  is equal to spread,  $S$

If spread,  $S$ , is known, height,  $h$ , may be found by the reverse construction

We believe that rectangle  $T2-T1-VT1-VT2$  is of sufficient importance to be designated by the special name, "the Depth Localization Rectangle," since that is really what it is

If  $H$  is made equal to 32 inches, and  $T2-T1$  to 3, 6, and 9 inches, respectively, three "Standard Depth Curves" can be charted (Graph I), showing the relationships of height,  $h$ , to spread,  $S$ , under these conditions

These curves can expeditiously be used in localization and planeographic procedures, provided the plates are taken, using the factors employed in deriving the curves

These curves we have also designated by the special name "Standard Depth Curves"

## II TECHNICAL DATA APPLIED TO LOCALIZATION

If one wishes to localize a single point,  $O$ , in space, all that is necessary is to expose it on a single plate under standard conditions. The vertical projection,  $VO$ , is easily obtained (see Figure 6). The height,  $h$ , is determined from "the Depth Localization Curve," using  $T20$   $T10$  as spread,  $S$ .

For localization of a single point, it may be feasible to project both images on a single plate. If, however, information pertaining to complex structures is desired, it is more expedient to make two exposures on two plates, one for each target position. Thus, if point,  $O$ , were exposed on two plates (see Fig 7)  $7A$  would represent the roentgenogram in  $T1$  position, and  $7B$  in  $T2$  position. The construction (see  $7C$  in Figure 7) would then consist of transcribing  $7A$  and  $7B$  upon the same sheet of paper and proceeding as before (compare  $7C$  in Figure 7 with Figure 6).

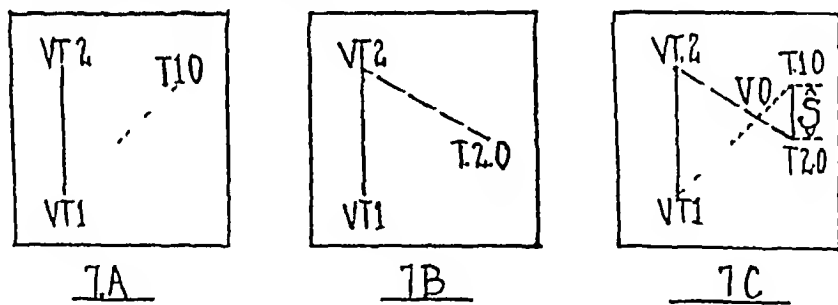


Fig 7

If any two given points are localized, it is a simple matter to determine their relationship in space.

Suppose, for example, we wish to determine the distance and obliquity of a line joining the tip of the coccyx to the tip of the anterior superior iliac spine. We first localize these points. From the localization data the information sought may be obtained as follows:

Expose the pelvis under standard conditions. In Figure 8  $S1$  and  $S2$  are schematic representations of such roentgenograms taken in  $T1$  and  $T2$  positions. The images of the coccygeal tip ( $C1$  and

$C2$ ) are marked on each film. The images of the iliac spine ( $S1$  and  $S2$ ) are similarly marked. These points are transcribed to the same sheet of paper (Fig 9). Each of the points is localized separately.

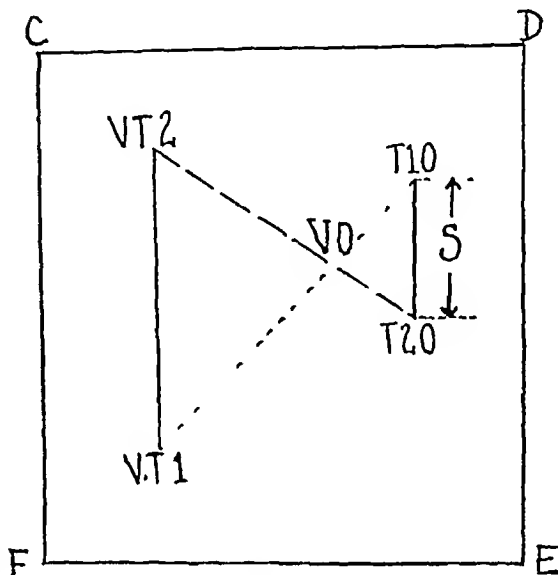


Fig 6

The vertical projections,  $1^{\circ}C$  and  $1^{\circ}S$ , of points  $C$  and  $S$  are thus recorded, as are their heights,  $h_C$  (height of coccyx above plate level), and  $h_S$  (height of iliac spine above plate level).

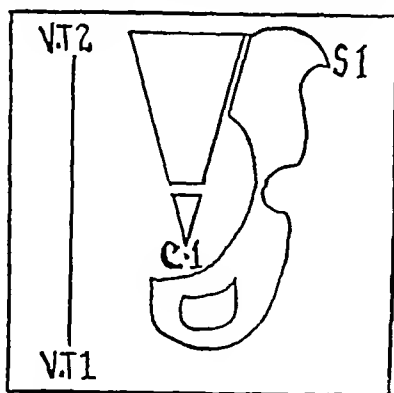
The length and obliquity are determined from the data secured by localization as follows:

- (1) Draw  $1^{\circ}C$   $1^{\circ}S$  (Fig 10) equal to  $1^{\circ}C$   $1^{\circ}S$  (Fig 9).
- (2) Draw  $1^{\circ}C$   $1^{\circ}C$  perpendicular to  $1^{\circ}C$   $1^{\circ}S$  and equal to  $h_C$ .
- (3) Draw  $1^{\circ}S$   $1^{\circ}S$  perpendicular to  $1^{\circ}C$   $1^{\circ}S$  and equal to  $h_S$ .
- (4) Connect  $C$  to  $S$ .

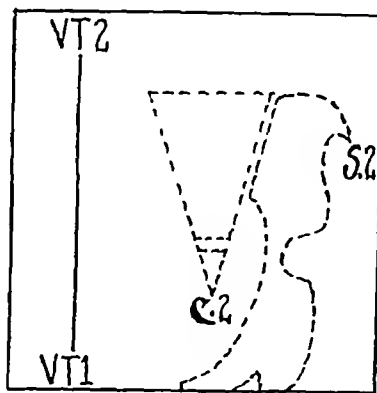
Line  $C-S$  represents the length, and angle  $S-C-V$  the obliquity

The above procedures are simple. They constitute all the construction necessary

points  $C2$  and  $C1$  superimpose. Similar points, one, two, three, four, five, etc., will then superimpose, and they will represent the planeogram sought (see Figure 11)



8-A



8-B

Fig 8

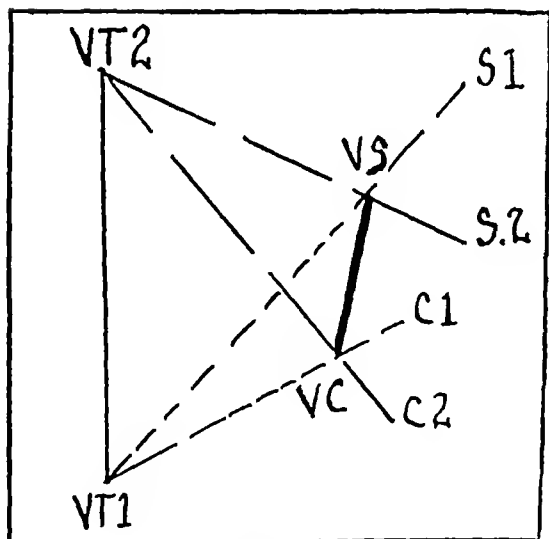


Fig 9

for all localization problems, regardless of their complexity

### III TECHNICAL DATA APPLIED TO PLANEOGRAPHY

Suppose we wish to determine the planeogram of the pelvic bones for that horizontal plane corresponding to the coccygeal tip. Proceed as follows

Superimpose 8-A upon 8-B so that

The height of this plane above the plate level may be obtained from "the Standard Depth Curve," using distance  $VT1$  as spread  $S$

This superimposition of standard roentgenograms for planeographic determinations introduces into roentgenology a new procedure of inestimable value. It not only localizes any given point, but it also defines it, in relation to others in the same horizontal plane.

Furthermore, if one roentgenogram is made to slide upon the other, using the vertical projections,  $VT2$   $VT1$  as an axis, one will be startled by visualizing various planeograms which appear, one a direct continuation of the other, as though one were traversing the actual anatomical structures. If the sliding motion is stopped, an individual planeogram becomes apparent, the height of which, above the plate level, may also be obtained from "the Standard Depth Curve."

### IV CLINICAL CONSIDERATIONS

Planeography may be employed for localization of points, for linear and angular mensuration, but its greatest field of usefulness is apparent when the procedure of "superimposition" of plates is

employed for the determinations of various planeograms. Let us dilate upon this phase more fully.

Suppose there is a calcific shadow in the

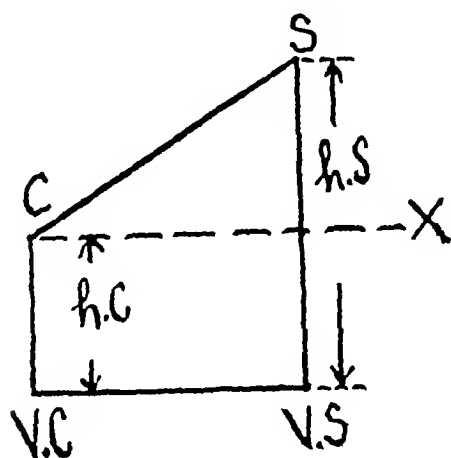


Fig 10

soft tissues of the bony pelvis and we wish to determine the plane in which it lies. We superimpose the standard plates so that the images of the calcific shadow superimpose. If it should lie in the same horizontal plane as the coccygeal tip, the images representing the coccygeal tip would then superimpose, otherwise they would not. Whichever similar points superimpose, represent the horizontal plane in which the calcific shadows lie.

Suppose there is a fracture of the skull which appears to involve the sella turcica, and we wish to determine with certainty whether it does or not. We superimpose the images of the sella. If the fracture actually involves the sella, that portion of the fracture in the sella will then superimpose.

If you wish to know whether the anterior superior iliac spines of both sides lie in the same horizontal plane or whether there is rotation, superimpose the images of one side. If they lie in the same horizontal plane, the images of the opposite side will superimpose.

If one wishes to know whether a calcific shadow lies in the plane of the kidney, planeography may be employed. If numerous calcific shadows are present, it is

possible to determine which lie in the plane of the kidney and which do not. We could multiply *ad infinitum* specific instances in which planeography could be em-

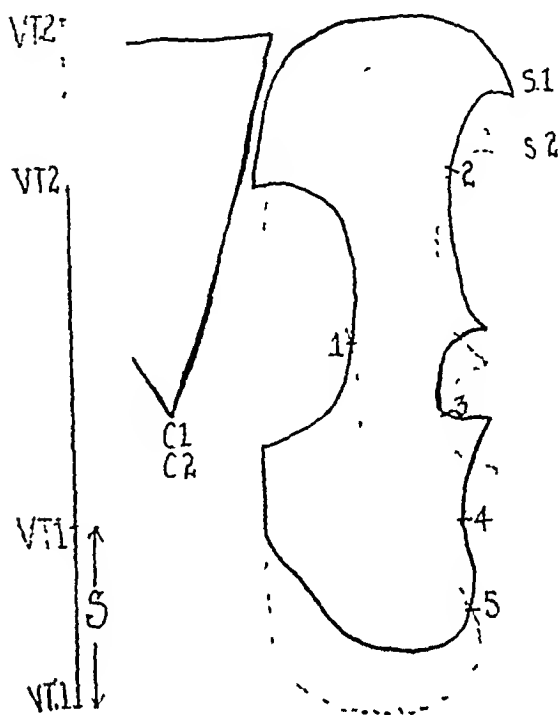


Fig 11

ployed. In general, however, it finds its greatest field of applicability in cases in which relationships are essential, as in localization, linear mensuration, angular mensuration, the determination of symmetries and asymmetries, rotations, involvement of structures by pathologic lesions, the determination of structural planes for whatever reason, etc.

#### V SUMMARY

In the foregoing treatise, we have demonstrated an original method for the determination of planeograms. In so doing, we have evolved "the Depth Localization Rectangle." We have constructed "Standard Depth Curves" and have demonstrated how they expedite localization. We have correlated planeography and localization. We have finally indicated some of the fields of applicability of planeography in clinical roentgenography.

Just a word about "the Standard Depth Curves." The distance 32 inches was employed for the simple reason that Thoms advises this distance in his method for the determination of pelvic measurements. Three inches was chosen as the spread of the targets for one of the curves, since such plates may also be viewed stereoscopically.

We believe it is imperative that the factors employed in localization be standardized and that depth curves be prepared under such conditions. We believe that these curves should be a part of every roentgen laboratory just as charts for cardiac measurements are. In all other radiographic procedures, standard routine measures are employed. We see

no reason why there should not be a "standard routine localization" procedure, in which "standard depth curves" are used for depth determinations. Localization could then be made practical and simple. The taking of the plates and the charting could then be done by practically anyone, whether or not he possessed mathematical training. From the standard plates taken for localization, planeograms could at the same time be made.

Finally, we wish to state that planeography opens new fields in research. Thus we have not touched upon, but we hope to report upon this phase at a later date, providing, of course, such research bears fruit.

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# THE EFFECT OF THE X-RAYS UPON THE FINE STRUCTURE OF THE PARENCHYMA OF THE THYROID GLAND

(SECOND ARTICLE)

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IN the preceding article<sup>1</sup> we discussed the action of x-rays in relation to the fine structural changes that are developed in the parenchyma of the normal thyroid gland. It would seem that the study of the results produced by this treatment upon the thyroid gland in the state of hypersecretion must surely be of greater interest. While in the clinic the x-ray is used as a therapeutic agent for the treatment of Basedow's disease, yet in the literature at our disposal we do not find any description of experimental morphologic investigations. We know that the laws applied to normal conditions cannot always be applied to pathologic processes and *vice versa*.

In the present investigation we want to solve the following problems:

(1) Whether the parenchyma of the thyroid is able to increase its secretory activity after partial thyroidectomy, *e.g.*, to give the compensatory hypertrophy, if this gland has undergone preliminary x-ray treatment.

(2) Whether the compensatory hypertrophy will develop after partial thyroidectomy, if the organ is radiated immediately after the operation or after a lapse of time.

## EXPERIMENTS AND METHODS

Rabbits were used for the experiments just as in the first case. In the first lot of rabbits for our present experiments the region of the thyroid was radiated with from 5 to 10 H E D using 1 H E D per day. (For the method of radiation, see Article I.) Immediately after the radiation or from 5 to 10 days later complete ex-

tirpation of the thyroid from one side was performed. This gland served as control No 1. Then in 20, 30, and 40 days, respectively, the rabbits were killed and the thyroid on the other side was removed and was used as the experimental gland. While this was being done to the experimental rabbit the normal rabbit was operated upon and killed. The thyroid removed before killing served as control No 2 and the thyroid from the other side removed after killing served as control No 3. The second series of experiments was performed as follows. The thyroid control No 1 of the normal rabbit was extirpated from one side. After the operation (usually from the third to fifth day), radiation of the animal was begun, giving 10 doses for from 15 to 20 days. The animals were killed just after the last radiation, or from 10 to 15 days later. The gland then removed was taken as the experimental gland. The other animals were operated upon in the same way, the extirpated gland was taken as control No 1 and 20 days later the other was radiated, receiving 10 doses during 15 days. Some animals were killed directly after the last radiation, the others 10 days later. The thyroid then removed was taken as the experimental gland. Simultaneously the control rabbit was operated upon, its extirpated gland served as control No 2, and then it was killed. The thyroid removed after killing was control No 3.

For the first series we used five experimental and five control rabbits, for the second series eight experimental and six controls. The method of making the preparations was the same as described in the first article.

<sup>1</sup> *Radiology*, July 1936, 27, 68-74.



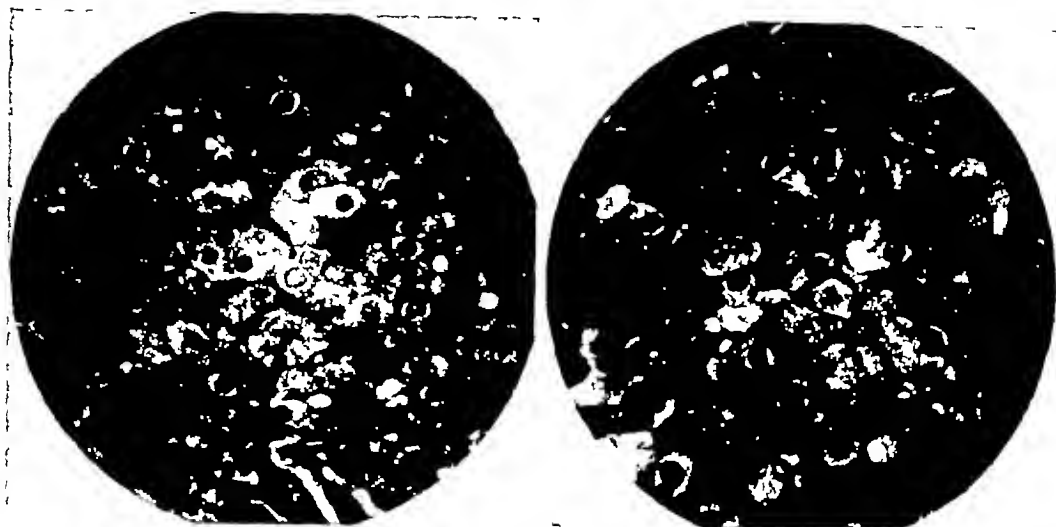


Fig 1 (Experiment 4) The thyroid gland control No 1 Staining for chondrioma by Kull's method  
The magnification for all photomicrographs is the same

Fig 2 (Experiment 4) The experimental thyroid gland Staining by Kull's method

#### OUR FINDINGS

First we shall speak about the first series of our experiments in which the radiation of the thyroid was done preliminary to partial thyroidectomy. We shall describe only one of the most typical experiments, because all of the experiments gave more or less the same morphologic data.

*Experiment No 4*—A rabbit, weighing 2,300 grams, was treated 15 days and received 10 H E D. Its thyroid from one side was completely extirpated, 10 days after the last radiation (Control No 1).

Histologic examination of this gland (Fig 1) shows it to consist completely of comparatively small follicles with diameters of from 5 to 32 microns, the epithelium of the follicles is of a low columnar or cuboidal shape, the height of its cells being from 5 to 8 microns, its nuclei are round, vesicle-shaped, their dimensions averaging 5.5 microns. Often the pycnotic nuclei are found in the epithelium. Chondrioma in the cells of the epithelium is rough and its regular disposition in a cell-body is lost. The lumina in most of the glandular vesicles seem empty because colloid lies in the form of a small clot upon the walls of the follicles thereby freeing the lumina of the follicles. In the individual follicles,

which are filled with colloid, the colloid is penetrated with large vacuoles. Thirty days after the thyroidectomy the remaining thyroid was extirpated and it served as the experimental gland.

#### EXAMINATION OF THE EXPERIMENTAL GLAND

The examination of the experimental gland (Fig 2) shows that it consists of follicles with diameters of from 8 to 32 microns. The follicular epithelium is of columnar and high-columnar shape and its cells are of large dimensions, having a height of from 13 to 16 microns. The nuclei in them are very large, being from 6.5 to 8 microns. Chondrioma in the epithelium of a gland is very robustly developed. It abounds in the cell-body and has a normal distribution, massing especially at the apical pole and along the border with the colloid.

In general, it is necessary to stress that in the present experiment chondrioma is more strongly developed than in the glands of the normal control animals. The lumina of glandular vesicles usually are empty and collapsed. Sometimes they are filled with a fine granular mass of colloid.



Fig 3 (Experiment 4) The thyroid gland control No 2 Staining by Kull's method  
 Fig 4 (Experiment 4) The thyroid gland control No 3 Staining by Kull's method

which in some places lies in the form of a fine nuclear net

*The Control Rabbit*—Male, weighing 2,980 grams, operation, partial thyroidectomy, the thyroid (control No 2) being completely removed from one side. Thirty days later the other thyroid (control No 3) was extirpated.

The histologic examination (Fig 3) shows that the gland (control No 2) is of normal structure, that is, the diameters of its follicles are from 16 to 48 microns. The epithelium of the follicle is of a cuboidal and sometimes columnar shape, being from 6.5 to 9.5 microns high. The sizes of the nuclei in it are from 5 to 6 microns. Chondrioma in the form of fine little sticks is regularly spread in the cell-body, often gathering more thickly at the apical poles of cells. Follicles are filled with homogeneous colloid, penetrated in some places with vacuoles.

The control gland No 3 (Fig 4) presents quite a different picture. Its follicles are not large in size, their diameter being from 16 to 38 microns. They are lined with epithelium the cells of which are very large, columnar or high columnar in shape and with a height of from 6.5 to 11 microns. Their nuclei are 6.5 microns. Often the

apex of these cells intrude like a dome into the lumen of the follicle, so that the apical poles of the cells of the epithelium appears like the top ridge of a fence. Chondrioma is very richly developed in the cells and is disposed regularly in the form of thickly massed grains, collected especially at the apical poles. The lumina of the follicles are either hollow and collapsed or filled with thickly vacuolated colloid.

Now we come to the description of the second series of our experiments in which the thyroid, left after partial thyroidectomy, was treated by x-rays. We shall describe here also only one experiment, because the data obtained from the various experiments were quite analogous.

*Experiment No 7*—A male rabbit, weighing 2,620 grams. The operation consisted of the complete removal of the thyroid (control No 1) from one side, 20 days later the other thyroid was treated for 15 days and received ten doses. The day following the final radiation, the rabbit was killed and the other gland (experimental gland) was removed.

*The Morphologic Examination*—The examination of the gland (control No 1) showed the usual normal structure but the



Fig 5 (Experiment 7) The thyroid gland control No 1 Staining by Kull's method  
 Fig 6 (Experiment 7) The experimental thyroid gland Staining by Kull's method

examination of the experimental gland (Fig 5) showed the following picture. Its follicles were decidedly enlarged in size in comparison with the follicles in the control gland, most of them being 58 microns in diameter. The follicular epithelium was of cuboidal or low cuboidal shape and reached a height of from 3.2 to 6 microns. Its largest nuclei were 5.5 microns.

There was a small amount of chondrioma in the cells, especially in the low flattened cell elements. The follicles with the higher epithelium were richer with chondrioma. The follicles were filled with a homogeneous mass of colloid which in some places was vacuolated. It seems important to point out that the organ had increased its colloid content considerably, the follicles had been enlarged in size and there had been a decided flattening of their epithelium. Chondrioma was poorly developed in the cells. We wish to stress the fact that in the present gland we found almost no pycnotic nuclei.

In the control rabbit we removed the thyroid (control No 2) from one side and 35 days later removed the thyroid (control No 3) from the other side. The structure of the thyroid control No 3 was analogous with the control No 3 of the first series of the present article.

#### DISCUSSION OF THE FOREGOING FINDINGS

The interpretation of the foregoing findings presents no special difficulty. In the series of experiments with preliminary radiation of the thyroid before partial thyroidectomy, we find the following condition. The cells of the thyroid treated by x-rays partially degenerate, as is seen from our first article. Some of the deteriorated cells, when the radiation is stopped, begin to reconstruct their structure little by little (see first article). The gland control No 1 shows just such a transitory condition. What do we find in the experimental gland which has undergone preliminary x-ray treatment and then, because of removal of the thyroid gland from the other side of the neck, was brought to the condition of having to supply increased secretion to the organism? Its morphologic examination thirty days after this operation shows that the epithelium of the follicle was changed from a cuboidal and low columnar form into a columnar and high columnar epithelium. The nuclei in the cells became larger. Chondrioma became extremely abundant and presented quite a normal appearance. The amount of chondrioma in the cells was found to be more abundant than in those of the normal

rabbits It shows that the cells of a gland undergo quite the same process of hypertrophy as previously described after partial thyroidectomy by the investigators Berezhovskiy, Breisacher, Trautmann, Halsted, Lasovsky, Wagner, Wicker, de Ligneris, Marins, Tchasovnicov, Zimnitsky, and Zatzvornitskaya and this coincides with what we found in the normal rabbit operated on in the same manner (see control No 3) What does this indicate? There is no doubt but that it indicates increased secretory work on the part of the gland The observations by Tchasovnicov, Anderson, Schmied, Galeotti, Trautmann, Isenschmid, de Quervain, Wegelin, and others prove that the larger the cell of the epithelium of the follicle, the stronger its function and *vice versa*, the low flattened epithelium in the glandular vesicles indicates a decreased activity of the gland The observation of Georgievsky, Koijma, Herring, Sirnev, Klivanskaja and Krol, Garnier, Lenhard, Langhaus, and others on feeding animals with a thyroid gland show that the follicular cells of the thyroid of animals so fed become very low, because the organ is brought to a condition requiring less secretion from its organism, due to the outside introduction of this secretion Yet the extremely abundant chondrioma in the cells indicates the increased secretory activity of these cells Now we come to the explanation of the phenomenon of the decrease of colloid content in the follicles of both the experimental and control rabbits after thyroidectomy This decrease is sometimes so pronounced that the lumina of many glandular vesicles seem empty and as if collapsed

Wegelin and Krause have already pointed out that the amount of colloid in the follicles of a gland represents on one hand a function of the secretory work of the epithelium of the follicles and, on the other, the result of the ejection of colloid from the glandular vesicles into the blood stream Due to partial thyroidectomy and because of the insistent requirement for secretion on the part of the organism

there is present such a great elimination of the secretion from the lumina of the glandular vesicles into the blood that even the secretory cells of the follicles which underwent hypertrophy fail to fill the follicles with their secretion Thus our experiments showed that the treated thyroid proved to be able not only to rebuild its structure up to normal, but, because of the increased demand on the part of the organism for greater activity, the thyroid responded with an increase of its secretion as well as with the phenomena of a compensatory hypertrophy But if after the same lapse of time after partial thyroidectomy we compare the radiated gland with the thyroid of a control (see in the first series of experiments, the experimental gland and control No 3), it is quite evident that the phenomena of compensatory hypertrophy of the control thyroid is much more pronounced Evidently this can be explained by the fact that the cells of the radiated thyroid have to rebuild their normal structure and then, in consequence of the trauma produced by the treatment, to increase their secretory power Therefore, it is more difficult for them than for the cells of a normal gland

Now let us discuss the second series of experiments The thyroid after partial thyroidectomy was radiated while the organism had made an increased demand for secretion Our findings demonstrate that in the thyroid of the experimental rabbit not only the phenomena of compensatory hypertrophy and increased secretion are not developed, but there was even a decrease of the function of the organ and a retention of colloid The following morphologic data prove this, the decrease in the height of the cells of the follicular epithelium, the decrease in the diameter of its nuclei and the impoverishment of chondrioma in the cells According to Anderson, Schmied, Galeotti Muller, Trautmann, Isenschmid, de Quervain, Wegelin, Tchasovnicov, and others, this condition of the cells indicates their decreased secretory activity We see that the diameters of the glandular vesicles are very

large because of the abundance of colloid. We cannot blame the superabundance of colloid in the gland upon increased production, since the secretion is decidedly decreased, therefore, it may be due to its retention in the organ. But this does not agree with the fact that there is an increased requirement for the secretion on the part of the organism.

The secretion should have been eliminated quickly in the most active way (see control No. 3, obtained by partial thyroidectomy of a normal rabbit).

Therefore, we do not understand the reason for the retention of colloid and we cannot offer any satisfactory explanation. Thus the  $\alpha$ -ray suppresses the necessity of cell elements to increase their secretion and their compensatory hypertrophy, which should have developed in them after partial thyroidectomy (see controls No. 2 and 3). On the contrary, they create the phenomena of a decrease of function and the retention of colloid in the organ. Here it will be well to draw attention to the extremely interesting fact that, as a rule, the  $\alpha$ -rays produce almost no phenomena of degeneration in the cells of glands of experimental animals. In the normal thyroid of radiated animals we observed the pycnosis of nuclei, vacuolization of protoplasm, and degenerative changes in chondrioma. But in our experiments with radiation of the thyroid, after partial thyroidectomy the phenomena of degeneration were almost entirely absent. It seems as if the  $\alpha$ -rays in these experiments acted chiefly quantitatively and not qualitatively upon the morphologic condition of the cells. The conclusion intrudes that the effect of  $\alpha$ -rays upon the cell is not always the same, and depends upon the functional condition of the cell. On the basis of both of our articles we arrive at the following conclusion: the parenchyma of the thyroid is rather resistant to the  $\alpha$ -rays. Their effect upon the cell of the thyroid is not the same, but depends upon the condition of the cell. In general, the x-ray action oppresses the secretory process in the thyroid and pro-

vokes a degeneration of the cells and the disintegration of a part of them. The degree of intensity of the depression of the functions and the phenomena of degeneration is in direct proportion to the dosage. The normal thyroid, having gone through a certain amount of degeneration and a decay of a part of its cell-elements, is able to re-establish morphologically its functions, after a lapse of time, approaching the normal. Even more, large doses of  $\alpha$ -rays, which kill a considerable amount of cell-elements in the organ, later can provoke a compensatory increased secretion in the remaining cells and also their hypertrophy.

The effect of large  $\alpha$ -ray doses corresponds to partial thyroidectomy. The  $\alpha$ -rays are also able to arrest the development of the compensatory hypertrophy, which should take place in the cells of the gland after partial thyroidectomy. Further, because of the disintegration of degenerated cells and of the undoubted influence of  $\alpha$ -rays upon the structure of colloid in the gland, a condition in the organism may be produced after radiation in which the products of degeneration and colloid are increasingly passed into the blood, that is, a hyperhormonization of the organism is created in the early days after radiation. On this basis we feel free to assume that the use of  $\alpha$ -rays for the treatment of the diseases of the thyroid, particularly of Basedow's disease, is not a simple procedure. First, the dosage should be in direct proportion to the strength of hypersecretion of the organ. Further, the given doses always—and especially at the beginning of the treatment—may provoke increasingly auto-intoxication because of the increased absorption of the products of degeneration of the gland cell-elements. X-rays, acting on the "island principle" and depending upon the strength of the dose and the resistance of the cells, also the variation of time after radiation, may bring about the phenomena of steady hypofunction of the organ or may redevelop the phenomena of Basedowism. All this proves that x-ray therapy of

Basedow's disease requires strict objective methods of control (e.g., the metabolism, the determination of the tone of the vegetative nervous system, the determination of the blood picture, Kottmann's reaction, etc.) over the function of this organ during radiation as well as for a considerable time thereafter. In addition to this, it is necessary to take into account the possibility of toxicosis at the beginning of the treatment.

### CONCLUSIONS

1 Cells of the normal thyroid treated by x-ray are not only able to re-establish their functions up to the normal, but under radiation, which acts upon them in a manner similar to a partial thyroidectomy, may bring about the phenomena of compensatory hypertrophy and also hypersecretion in the remaining intact cells.

2 The x-rays having been used for the treatment of the thyroid of a normal animal, after partial thyroidectomy, that is, during the time of the more intensely functioning cell-elements, may stop the development of their compensatory hypertrophy and hypersecretion and may even decrease the activity of the cells below the normal.

The x-ray treatment of Basedow's disease should be strictly individual for each case and it should be obligatory that it be carried on under the control of the objective

methods for determining the functions of the thyroid during the time of treatment and for a considerable time thereafter.

At the beginning of the treatment it is necessary to pay strict attention to the phenomena of increased auto-intoxication.

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# FRACTURES OF THE SPINE

REPORT OF 173 CASES

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**R**OENTGENOLOGIC consideration of the spine has established the presence of a large group of congenital anomalies and defects. Added to these normal differences there is the influence of disease, including the various hypertrophic changes resulting from age, posture, and occupation. Structural changes may also give rise to a confusing picture, which may be difficult to differentiate from fracture. These anatomic variations are often complicated in the same spine by traumatic and non-traumatic lesions, or accompanied by the presence of pathologic conditions which may be attributed to trauma or other causes. Experience has shown that this complexity of conditions gives rise to a vertebra that is not entirely constant in appearance.

Congenital anomalies are rare in the cervical and dorsal regions but extremely common in the lumbar and lumbosacral segments. In 1931, the writer reviewed 1,122 consecutive genito-urinary examinations and found 38.7 per cent of anatomic variations in the lumbar and lumbosacral segments. Bohart and Cushway and Maier made a routine x-ray examination of all individuals entering the employment of the Belt Railway Company of Chicago, and found that approximately 44 per cent of 1,000 symptomless spines revealed some type of anomaly. *Spina bifida occulta* was the most frequent variation noted, and sacralization was the next in frequency. The above mentioned authors concluded that anatomic variations do not predispose to prolonged disability or increased tendency to injury unless accompanied by hypertrophic changes. The importance of these anatomic variations should not be over-emphasized, but familiarity with them is necessary in order to avoid error in mistaking these congenital defects for fracture.

The following tabulation shows the

level of involvement in a series of 173 cases of fractured vertebrae observed in the x-ray department of the Scott and White Clinic, and the Gulf, Colorado and Santa Fe Hospital, during the past ten years.

	Scott and White Clinic	G C and S F
Sacrum	12 cases	2 cases
Transverse processes	15 cases	4 cases
Cervical vertebrae	11 cases	3 cases
Dorsal vertebrae	25 cases	5 cases
Lumbar vertebrae	44 cases	13 cases
Dorso-lumbar vertebrae	35 cases	4 cases
Total	142 cases	31 cases

Anatomically, the spine consists of 33 segments. In the adult, nine of these are fixed, composing the sacrum and coccyx.

Further discussion will be limited to a consideration of fractures of the presacral or movable vertebrae and, briefly, their differential diagnosis.

The following tabulation shows the distribution of the 201 fractured bodies in 140 cases, averaging 1.4 segment to the case.

	Cervical	Dorsal	Lumbar
First	1	1	50
Second	2	0	26
Third	0	1	9
Fourth	1	1	11
Fifth	7	1	5
Sixth	8	5	
Seventh	1	5	
Eighth		6	
Ninth		6	
Tenth		11	
Eleventh		14	
Twelfth		29	
	20	80	101

The most common site of fractures in this series of cases was in the dorso-lumbar region. Forty-two (37 per cent) of the 115 cases observed in the Scott and White Clinic were women, and 73 (63 per cent) were men. Ninety-three of the 140 presacral cases revealed fractures of single segments: five cervical, 31 dorsal, and 57 lumbar. The remaining 47 cases presented multiple fractures. Eight of the cases of fracture in the cervical region presented 17

fractured segments The 39 cases of multiple fractures in the dorso-lumbar region revealed 91 fractured segments, with associated dislocation in 14 cases

The 19 cases of fractured transverse processes showed involvement of 37 transverse processes Seven cases were associated with fractures of the vertebræ, and three of the transverse processes of the fifth lumbar were associated with fractures of the sacrum

The tabulation below shows the etiology in 78 (68 per cent) of the 115 cases of presacral vertebræ observed in the Scott and White Clinic

Automobile accident	42 cases
Falling from a height	22
Diving	5
Injured by train	4
Horse drawn vehicle	3
Acroplane crash	2
	<hr/> 78 cases

The tabulation below shows the occupation of the 29 cases with fractures of the presacral region observed at the Santa Fe Hospital

	Cases	Duty	Cause of Injury	Old Fracture	Paralysis
Laborer	7	7	0	0	3
Switchman	6	5	Struck by speeding car	0	2
Brakeman	4	4	0	0	1
Enginer	3	0	Elevator cable broke		
			Fell off ladder	2	1
Conductor	2	2	0	2	1
Machinist helper	1		0	1	0
Coppersmith	1	1	0	0	1
Boilermaker	1	0	Car accident	0	0
Draftsman	1	0	Football 1922	1	0
Signal helper	1	1	0	0	0
Clerk	1	0	Motor cycle	0	0
Stenographer	1	0	Riding in car	0	0
Total	29	15	7	6	9

The most common injury to the spine is a compression fracture of the body According to Albee this injury constitutes about 80 per cent of vertebral fractures Spinal fractures are usually simple but may be compound The etiologic factor is a direct or indirect force applied to either end

of the spine, resulting in hyperflexion or hyperextension of the spinal column

Fractures in which there is a demonstrable injury to the spinal cord may show transitory or complete paralysis Many patients so paralyzed may respond to careful, conservative treatment, while others are hopeless from the very start When the cord is severely torn or crushed, only slight improvement is to be expected, because the cord tissue has little power to regenerate

A much larger and more important group of cases is that in which no signs of cord lesion can be elicited Such fractures may involve either the accessory portion of the vertebra or the body itself Statistics regarding the exact percentage of vertebral fractures occurring with and without cord symptoms are rare In 1925, Sherwood Moore wrote "Since 1911 there have been observed in the Roentgen Department of Washington University 69 fractures of the spine, about 3 per cent of all fractures observed during the same period Of the total number of cases, 21 (30 per cent) were acute, with a classical picture of fracture, 48 cases were adventitious discoveries" Forty-four (31 per cent) of the 140 cases of fractures of the bodies of the presacral vertebræ observed in our series presented the classical symptoms of fracture

Due to the fact that only a comparatively small percentage of cases of fractures of the spine has been proved by laboratory findings, operations, or postmortem examinations, it seems safe to assume that vertebral fractures heal in the same manner as fractures elsewhere, that is, fractures of the vertebræ almost immediately undergo a process of repair and callus formation The body of the vertebra at first is comparatively soft and may undergo a process of rarefaction or attrition, being readily compressed further before the callus has had time to consolidate Unless proper treatment is instituted, and the injured vertebra protected for a long time, there may be after several weeks or months of weight bearing increased deformity, accompanied by pain and weakness in the



spine, and neuralgic and motor disturbances in the legs

There remains to be discussed Kummell's disease, a condition first described in 1895 as non-tuberculous osteitis of the vertebral bodies, accompanied by softening and collapse of a body. The literature has been well reviewed in recent papers by Baker, Blaine, Jones, and Kummell. The exact nature of the condition is perhaps not well understood and there remains a great deal of doubt and confusion. Osgood and Steindler believe there is no doubt of the existence of the condition as a clinical entity. On the other hand, O'Brien, George and Leonard, and other authorities express considerable doubt as to the occurrence of any such process as Kummell described, and suggest that many of the cases are unrecognized fractures of the spine.

A careful perusal of the case reports indicates the possibility of many of these cases being simply small, unrecognized fractures of the spine with delayed symptoms. Unquestionably many of the reports of so-called Kummell's disease are simply delayed symptoms following an unrecognized fracture of the spine. A diagnosis of Kummell's disease is hardly justified unless a careful x-ray examination immediately after the injury is negative and is followed later by positive findings in the roentgenogram. No doubt, there are authentic cases in which the criteria set forth for the diagnosis of Kummell's disease are fulfilled. At the same time we must bear in mind that this disease entity is extremely uncommon.

Fracture of the spine must be differentiated from metastasis, tuberculosis, osteomyelitis, syphilis, old hypertrophic arthritis, and the natural collapse of the bodies of the vertebrae with excessive calcium absorption in old age.

Metastatic lesions are nearly always carcinomatous, although Hodgkin's disease may be encountered. The rather rare osteoblastic type of secondary malignancy may produce a marble-like bone of great density, usually without the occurrence of wedge-shaped vertebrae. The most frequent destructive or osteoclastic type usu-

ally produces irregular, moth-eaten areas of destruction. The intervertebral discs are destroyed, whereas in fracture they remain intact. Tuberculosis and osteomyelitis are recognized on the roentgenogram by bone destruction and narrowing of the intervertebral discs. The vertebra becomes wedged-shaped, this condition being more marked in tuberculosis. In tuberculosis there are rarely bone proliferation and callus formation, whereas in osteomyelitis these changes are present. The history of the case and the absence of trauma are important factors in the establishing of a diagnosis of osteomyelitis and Pott's disease. Syphilis, on the other hand, is usually accompanied by extensive new bone formation, and the extent of the lesion is more marked than the symptoms would indicate. Osteoarthritis, or spondylitis, often presents great difficulty in diagnosis, especially if the injury producing the alleged fracture is of several months' duration. The new bone in spondylitis is in the form of spurlike formations and is laid down along the margins of the vertebrae in the form of a fringe, which may later bridge across and fuse. Frequently there is absorption of the lime salts from the body of the vertebrae in the senile, giving rise to a gradual collapse of the bodies. This produces a kyphosis, which presents a smooth, rounded curve of the bodies of the vertebrae, differing from the irregular angulation in fracture of the spine.

The diagnosis of fracture of the spine is readily associated with severe trauma and the classical symptoms accompanying these fractures. It must be remembered that a very slight trauma may cause a fracture or dislocation of the vertebrae. Many vertebral fractures in which there is no demonstrable injury to the spinal cord are overlooked, simply because their immediate symptoms do not seem to be of sufficient gravity to suggest a fracture. Nevertheless a history suggestive of fracture may be obtained from many patients who have had osteoarthritis, aggravated by injury. Similar mistakes may occur in connection with osteomyelitis and Pott's disease.

The physical examination should be made as complete as possible because many of the physical signs may be overlooked, only to show up on a later examination, thus deceiving the examining physician or leading him to believe that a progressive lesion is present. The physician or surgeon can give satisfactory directions for the x-ray investigation of a sufficient area of the spine only after a careful and thorough physical examination.

The final diagnosis must often depend on the roentgenogram. The number of unrecognized fractures of the spine can be reduced to a minimum with the aid of adequate x-ray technique and painstaking interpretation of the roentgenograms, based on anatomic and pathologic facts. Roentgenograms taken in the anteroposterior and lateral planes will furnish the most convincing evidence of vertebral fractures. A good lateral view will not infrequently be the deciding factor.

It is well to remember that a disabling fracture of the spine may be the result of a seemingly simple or trivial accident. Many cases of compression fractures of the vertebrae without classical symptoms may recover with little treatment, but it is useless to assume that all will do so. Only the routine x-ray examination will prevent frequent error in the handling of back-injuries. Routine x-ray examinations in every case of spinal injury will at times show a lesion that cannot be positively demonstrated in any other way.

#### SUMMARY

Fractures of the spine are quite common, comprising 6 per cent of the total number of fractures observed in the Scott and White Clinic over a ten-year period.

Anatomic variations, because of their frequent occurrence, deserve special consideration in the examination of vertebral injuries. They should not be over-emphasized but should be recognized and reported in order to avoid error.

Every case of spinal injury should have the advantage of a careful x-ray examination.

The early recognition of spinal fractures is too frequently overlooked. This may be due to inadequate history and physical examination or to insufficient x-ray study, the latter including poor technique, failure to examine a sufficient area of the spine, or the omission of lateral views.

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spine, and neuralgic and motor disturbances in the legs

There remains to be discussed Kummell's disease, a condition first described in 1895 as non-tuberculous osteitis of the vertebral bodies, accompanied by softening and collapse of a body. The literature has been well reviewed in recent papers by Baker, Blaine, Jones, and Kummell. The exact nature of the condition is perhaps not well understood and there remains a great deal of doubt and confusion. Osgood and Steindler believe there is no doubt of the existence of the condition as a clinical entity. On the other hand, O'Brien, George and Leonard and other authorities express considerable doubt as to the occurrence of any such process as Kummell described, and suggest that many of the cases are unrecognized fractures of the spine.

A careful perusal of the case reports indicates the possibility of many of these cases being simply small, unrecognized fractures of the spine with delayed symptoms. Unquestionably many of the reports of so-called Kummell's disease are simply delayed symptoms following an unrecognized fracture of the spine. A diagnosis of Kummell's disease is hardly justified unless a careful x-ray examination immediately after the injury is negative and is followed later by positive findings in the roentgenogram. No doubt, there are authentic cases in which the criteria set forth for the diagnosis of Kummell's disease are fulfilled at the same time we must bear in mind that this disease entity is extremely uncommon.

Fracture of the spine must be differentiated from metastasis, tuberculosis, osteomyelitis, syphilis, old hypertrophic arthritis, and the natural collapse of the bodies of the vertebrae with excessive calcium absorption in old age.

Metastatic lesions are nearly always carcinomatous, although Hodgkin's disease may be encountered. The rather rare osteoblastic type of secondary malignancy may produce a marble-like bone of great density, usually without the occurrence of wedge-shaped vertebrae. The most frequent destructive or osteoclastic type usu-

ally produces irregular, moth-eaten areas of destruction. The intervertebral discs are destroyed, whereas in fracture they remain intact. Tuberculosis and osteomyelitis are recognized on the roentgenogram by bone destruction and narrowing of the intervertebral discs. The vertebra becomes wedged-shaped, this condition being more marked in tuberculosis. In tuberculosis there are rarely bone proliferation and callus formation, whereas in osteomyelitis these changes are present. The history of the case and the absence of trauma are important factors in the establishing of a diagnosis of osteomyelitis and Pott's disease. Syphilis, on the other hand, is usually accompanied by extensive new bone formation, and the extent of the lesion is more marked than the symptoms would indicate. Osteoarthritis, or spondylitis, often presents great difficulty in diagnosis, especially if the injury producing the alleged fracture is of several months' duration. The new bone in spondylitis is in the form of spurlike formations and is laid down along the margins of the vertebrae in the form of a fringe, which may later bridge across and fuse. Frequently there is absorption of the lime salts from the body of the vertebrae in the senile, giving rise to a gradual collapse of the bodies. This produces a kyphosis, which presents a smooth, rounded curve of the bodies of the vertebrae, differing from the irregular angulation in fracture of the spine.

The diagnosis of fracture of the spine is readily associated with severe trauma and the classical symptoms accompanying these fractures. It must be remembered that a very slight trauma may cause a fracture or dislocation of the vertebrae. Many vertebral fractures in which there is no demonstrable injury to the spinal cord are overlooked, simply because their immediate symptoms do not seem to be of sufficient gravity to suggest a fracture. Nevertheless a history suggestive of fracture may be obtained from many patients who have had osteoarthritis, aggravated by injury. Similar mistakes may occur in connection with osteomyelitis and Pott's disease.

neither the quantity nor the quality of the dose received by the tissue, which it is desired to influence, bears any simple relation to the dose administered to the patient. This is because the tissue receives a large part of its effect from energy scattered by the surrounding tissues, which may be degraded to much longer wave lengths by the scattering process.

The problem is simplified by the wave length independence of the response of small test objects, which restricts the importance of wave length to the question of penetration.

Since the dose inside the body cannot be measured directly by means of the standard open chamber, recourse has been had to thimble type chambers. Even these cannot be used with the living patient except on the surface or within the mouth, rectum, or vagina, so that it is necessary to fall back on measurements in water phantoms or, preferably, cadavers. This method is not ideal, for it is difficult to be sure that the radiation at a depth does not include wave lengths longer than those for which the chamber is calibrated. Also, such chambers are necessarily so large that it is impossible to place them in such a way as to be sure of always measuring properly the dose received by the cells of the skin. And the skin dose is important because of legal complications.

Because of the difficulty of specifying intensities inside the human body, it is still common practice to correlate clinical results for specific parts of the body with the external exposure conditions, namely, intensity measured in air, voltage, filtration, skin-target distance, area of portal, etc. Water phantom data then serve as a rough guide to the intensity changes to be expected when the external conditions are changed.

#### MINUTES FOR DOSE AT 1,000 KILOVOLTS

The distance travelled by the ionizing secondary electrons increases rapidly with the voltage of the x-rays by which they are produced and becomes large as compared

to the size of a cell. As a result, if small test objects such as *Ascaris* eggs are exposed to x-rays generated at 1,000 kv, it is necessary to specify not only the intensity of the x-rays, but also the configuration and composition of all surrounding material from which ionizing electrons can reach the eggs. This is most readily done if the test object is closely surrounded by a layer of tissue-like material at least as thick as the effective range of the electrons. Then the electrons which enter the test object from the surrounding material will just compensate for the loss of electrons from the test object to its surroundings.

Under therapy conditions, the cells receive full electron compensation except at the surface, where, with a beam which is limited by diaphragms, as is always the case with x-rays, there will be a shortage of electrons. It is a question whether the deficit which exists at the depth of the dermal capillaries concerned with erythema production is sufficient to be of practical importance at 1,000 kilovolts. We are not concerned here with the total length of the crooked tracks of the electrons, as revealed in Wilson cloud chamber photographs, but rather with the effective range obtained from experiments on the penetration of electrons through thin plates. According to the data of Varder (18), the fastest forward recoil electrons produced in appreciable amount at a tube voltage of 1,000 kv can be detected through a thickness of tissue of about two millimeters. However, the fraction of the total incident electron energy which can penetrate to this depth is extremely small (11), and probably is not significant at depths of more than about 0.5 millimeter. Furthermore, the surface deficit is by no means complete, because of electrons contributed by the air and filter in a greater or less amount depending on diaphragming conditions. Even with radium gamma rays which give some recoil electrons detectable through a centimeter of tissue, Stahel, Simon, and Joiner (19) were unable to observe significant differences in the erythemas produced even when foils of different metals were placed

# SOME PHYSICAL PROBLEMS OF HIGH VOLTAGE X-RAY THERAPY<sup>1</sup>

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A NUMBER of physical problems must be solved before the dosage of x-rays produced at voltages from 400 to 1,000 kv can be placed on a basis as definite as the present system of 200 kv therapy. Some of these questions will be outlined and briefly discussed under headings dealing with the requirements of the biologist working with narrow beams and small test objects, and of the therapist irradiating tissues at a depth.

When living cells are exposed to x-rays of sufficient intensity, injury to the cells results. The problem of therapy is to administer this destructive agent with the most benefit and the least damage to the patient, for there is always damage.

The part of the physicist in this task is to analyze and control the physical factors involved in an exposure to x-rays in order to provide a reproducible and systematically variable range of conditions of irradiation. These conditions can then be correlated by the biologist with his observations on the effects produced in individual cells and isolated tissues, and finally by the clinician with the therapeutic results obtained with patients.

In the time allotted it will, of course, be impossible to attempt a detailed technical discussion of the announced subject, instead, my aim will be to indicate in a general way the extent to which the physicist is at present able to extend to the high voltage range the system of dosage which he has developed for voltages up to 200 kilovolts.

## SYSTEM OF DOSAGE IN USE FOR 200 KV THERAPY

With regard to the effect of irradiation

<sup>1</sup> Presented before the Radiological Society of North America, at the Twenty-first Annual Meeting at Detroit, Dec 2-8 1935

on a small test object, such as a single cell or a small particle of tissue, the relevant physical factors may be distinguished as (1) rate of production of kinetic energy of high speed ionizing electrons in unit volume per second, (2) duration of exposure, and (3) wave length of the absorbed radiation.

No satisfactory experimental method having been found for measuring directly either the energy of secondary electrons or the amount of ionization produced in tissue or fluids, the production of ionization in a gas was adopted as a basis of dosage. Thus, the intensity of irradiation of a small test object exposed to a beam of x-rays is specified by stating the ionizing effectiveness of the beam in free air as expressed in roentgens per minute and measured in a standard open air ionization chamber or with a calibrated thimble chamber.

For the specification of wave length, direct and indirect methods have been provided which are adequate, if not always convenient.

Using the physical basis of dosage here outlined, the study of small biologic test objects has shown that the response of such objects to an exposure measured in roentgens may be regarded, at least to a first approximation, as independent of wave length up to 200 kv and higher.

In what has been said so far, we have been thinking about the needs of the biologist in his attempt to correlate exposure conditions with the biologic effect on cells or small particles of tissue which can be exposed directly to the source of radiation. We now come to the more difficult problem presented by the therapist who wants a set of reproducible exposure factors with which to correlate his results when irradiated cells are located in a large mass of absorbing material exposed to a wide beam. Here

tion Some of the more discordant results were obtained with chambers the walls of which were not thick enough to exclude electrons from surrounding objects. Approximate constancy of ionization for wall materials of atomic number up to aluminum has been found by two experimenters (5, 16). On the other hand, Mayneord and L. H. Gray are both reported to have found differences within this range of wall material (8). An outstanding serious discrepancy of 30 per cent between values obtained with thick graphite chambers by Mayneord and Roberts (14) and by Friedrich, Zimmer, and Schulze (6) has been removed by revised values which have just been published by Friedrich and Schulze (5). The average of the recent measurements with thick-walled chambers now agrees closely with the earlier value of Glasser and Mautz (7).

If it could be established that suitably designed thimble chambers can measure gamma rays accurately in roentgens, it probably would follow that such chambers would also measure filtered 1,000 kv x-rays correctly.

The statement in the last paragraph applies to measurements in air without scatter. On the other hand, in a water phantom a part of the radiation is degraded, as a result of repeated scattering, to wave lengths for which the photo-electric type of x-ray absorption becomes important even in light elements. The possibility of making correct "air-wall" measurements with such a mixture of wave lengths is much more doubtful than in the case of short wave lengths for which the Compton scattering type of absorption alone is effective. Michelmeckel (15) has obtained results with walls composed of carbon and silicon in different proportions which he interprets as indicating the impossibility of making a thimble chamber which will have wave length independence over the whole x-ray range, and at the same time be "air-walled" in the sense of giving correct absolute values in roentgens. The question obviously calls for further study. In the meantime, data by various workers,

Failla (3) and Keller (12), for example, are sufficient to show the importance of even small changes in wall composition on depth measurements.

It is worthy of note that the values of gamma-ray intensity obtained by thimble chambers and other indirect physical methods of measurement average 60 per cent higher than the values obtained from biologic indicators which have been calibrated against standard open chambers for x-ray wave lengths (2). The advantages offered by *Drosophila* eggs as a means of measuring directly the biologic effectiveness of radiation over the whole range of wave lengths used in radiotherapy will be discussed in another paper in this symposium. From a physical standpoint it may be said that for measurements in water or tissue these eggs are nearly ideal, since the whole problem of "air equivalence" of walls ceases to exist. Also, their small size of not over 0.2 mm diameter is very advantageous in places where the intensity is changing rapidly with position, as in the case of measurements close to a radium source, or at the surface of a water phantom.

As an interesting example of the difficulties which are still being discovered in connection with the indirect physical methods of measuring free air ionization in roentgens for gamma rays, it may be mentioned that Stahel (16) has recently found that his calibration of an ionization chamber by calorimetric measurements of gamma-ray absorption in hexane gives a value for energy in ergs per roentgen over 100 per cent higher than the results obtained by other methods. He ascribed this difference to exothermic chain chemical reactions initiated by the gamma-ray energy and affecting the calorimetric measurements. It would seem possible that in some absorbing materials not only additional heat but also additional ionization might be produced by such secondary chemical processes.

#### MEASUREMENT OF WAVE LENGTH

Crystal spectrometers have been designed by a number of experimenters,

in contact with the skin, although such differences were readily obtained with *Drosophila* eggs, photographic films, and a thin-walled ionization chamber

Thus it seems unlikely that at 1,000 kv any very considerable diminution in skin damage will be found to result from electron deficit at the surface. This effect should, of course, not be confused with the effect of back-scattered  $\gamma$ -rays on skin dose at different wave lengths. This latter question has been discussed by Lauritsen in some detail (13)

The definition of the "roentgen" is ambiguous with regard to the inclusion of the ionization due to the different types of secondary  $\gamma$ -rays generated in the test volume of air. For this reason, and because of the inadequacy of intensity in roentgens as a specification of surface dose, it has been urged that a better experimental basis of dosage should be developed. As yet, however, no substitute physical method is available. Pending the development of such a method we may consider the possibility of measuring intensity in roentgens up to 1,000 kilovolts

#### OPEN CHAMBER MEASUREMENTS

The possibility of measuring gamma rays in roentgens by the open chamber method has been investigated by various workers (1, 4, and 14)

The definition of the "roentgen" demands that all of the ionization due to the secondary electrons produced in the test volume of air should be measured. In the open chamber, as applied at ordinary voltages, this is accomplished through a process of compensation whereby the ionizing electrons which are lost from the test volume are replaced by others entering from the outside. With gamma rays, this compensation would require a chamber several meters long. The use of such a chamber with available quantities of radium seems to be out of the question on account of serious technical difficulties connected with diaphragming, current measurement, and disturbing effects of secondary radiations. These same difficulties, in a lesser degree,

apply to  $\gamma$ -rays produced at voltages above 400 or 500 kilovolts. It may be possible with suitable precautions to make open chamber measurements up to 1,000 kv with reasonable accuracy, but the question calls for further study. In any case the apparatus must be inconveniently bulky, the distance between the limiting diaphragm and the collector being especially important (1)

The difficulty encountered in using the open chamber with high voltage  $\gamma$ -rays and gamma rays has stimulated considerable interest in the concept of an "air-walled" chamber, introduced years ago by Fricke and Glasser. The definition of the "roentgen" demands that all ionization resulting from energy absorbed in material other than air shall be excluded from the measurement. According to the air-walled chamber idea it should be possible to compress the air surrounding the test volume into a solid shell without altering the compensating interchange of secondary electrons between the test volume and its surroundings. If, instead of this imaginary shell of compressed air, we substitute a wall of material having the same atomic properties as air with regard to the absorption of  $\gamma$ -rays and secondary electrons, then we would have what is called an air-walled chamber which should measure  $\gamma$ -rays directly in roentgens. Encouragement was given to this point of view by some theoretical treatments of the problem, especially that of L. H. Gray (9). Recently a number of authors have made measurements on radium with thimble-type chambers and published their results expressed in roentgens. Other writers, for example Edith Quimby (17), have insisted that it is not proper to express such measurements in roentgens without first re-defining the roentgen.

Considerable weight has been lent to the latter point of view by the large discrepancies which have existed between the results obtained by different investigators for the intensity of the gamma ray output of radium. However, recently published work has somewhat improved this situa-

tion Some of the more discordant results were obtained with chambers the walls of which were not thick enough to exclude electrons from surrounding objects. Approximate constancy of ionization for wall materials of atomic number up to aluminum has been found by two experimenters (5, 16). On the other hand, Mayneord and L. H. Gray are both reported to have found differences within this range of wall material (8). An outstanding serious discrepancy of 30 per cent between values obtained with thick graphite chambers by Mayneord and Roberts (14) and by Friedrich, Zimmer, and Schulze (6) has been removed by revised values which have just been published by Friedrich and Schulze (5). The average of the recent measurements with thick-walled chambers now agrees closely with the earlier value of Glasser and Mautz (7).

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#### MEASUREMENT OF WAVE LENGTH

Crystal spectrometers have been designed by a number of experimenters,



which permit measurements with voltages up to the neighborhood of a million. These measurements are difficult because of the extremely small deviations suffered by such short wave lengths, and they are entirely unsuitable for routine use outside of a physical laboratory. Most of the observations with high voltages have been correlated with voltage measurements made with large sphere gaps, using the calibration curves of the American Institute of Electrical Engineers. These values have recently been found to be too high by about 7 per cent in the neighborhood of 800 kv by two independent methods (10). Likewise Tuve, at Washington, found that his sphere gap was indicating 30 per cent too high, presumably due to corona and space charge in the air of the room, thus indicating that sphere gap measurements should be used only with considerable discretion. Lauritsen has found that, contrary to the case with low voltages, a point gap is more dependable than a sphere gap at high voltage. As with low voltages, the values obtained by absorption measurements on the radiation emitted may be used as a measure of quality. Such measurements demand considerable care in the choice of experimental conditions and in the interpretation of the data.

It may be mentioned that the measurement of tube milliamperage, which at low voltages is so useful as a means of maintaining a constant output, encounters complications at high voltages partly in connection with wave form effects and partly as a result of gas discharges in the tube.

#### SUMMARY

Summarizing, it may be said that the difficulties which are met in making open chamber and "air-wall" chamber measurements up to 1,000 kv have not yet been

completely solved. No physical method at present available can be depended on to measure correctly the mixture of primary and degraded radiation found at a depth either in a water phantom or under therapy conditions in a patient. The ionization produced at the surface of a water phantom by a diaphragmed beam is not uniquely determined by the intensity of the direct and scattered x-rays at the surface because of incomplete compensation of long range electrons. Whether this fact possesses any practical importance with regard to skin erythema for 1,000 kv x-rays is doubtful.

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# THE BIOLOGICAL ROENTGEN<sup>1</sup>

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MEASUREMENT of the intensity of  $\alpha$ - and gamma-rays by means of living organisms and tissues as indicators of dosage has been a common practice for many years. As early as 1915, Ritter correlated the amount of effect of  $\alpha$ -rays on growing seedlings with doses measured by the pastilles then in use. Later Jungling employed both beans and mice for similar measurements. The mice and other large laboratory animals proved unsatisfactory for the purpose because of complications which were not then understood. To simplify the experiment and to obtain clear-cut results, cells and small organisms have been found more useful. In these, scattered radiation can be disregarded, the entire organism is uniformly irradiated, and the complications met with when a small part of a large body is exposed are absent. The variety of biological materials which have been used in these experiments is surprising. Bacteria, yeasts, and spores of various kinds, algae and seeds of different sorts, protozoa, the eggs of worms, insects, frogs, and salamanders, tadpoles, chick embryos, and larval tissues, water fleas, tissue cultures and tumor particles—all of these have yielded valuable information for the solution of radiological problems.

The reaction which is most often used as a criterion of the effect of radiations involves a fundamental characteristic of living protoplasm, namely, the power of growth and repair. A sufficient dose alters the rate and direction of growth. Cell division is slowed down with the result that development is stunted or abnormal, or it may be completely stopped by death. Even in adult tissues the

effect which is measured is of the same order. Radiations retard the process of regeneration, so that damaged cells cannot be replaced by healthy new growth, and injury ensues. This change in the rate and direction of growth is most easily measured in small, actively growing cells and organisms.

The relation between dose and amount of effect is illustrated by experiments on the eggs of the fruit fly, *Drosophila*. The criterion of effect is the proportion of eggs in a sample which survive and hatch as larvæ. In Figure 1 are shown the results of more than two hundred tests in which various doses, measured in roentgens, were administered under definite experimental conditions. It is clear that the percentage of eggs surviving after each dose is fairly constant. From the curve, drawn to fit the data, one may determine the survival percentages which may be expected to follow any dose within the range shown in the figure. The same procedure is carried out when other kinds of test objects are used. Thus, the ratios between the number of mitoses in irradiated tissue culture preparations and in the controls, or the proportion of bacteria which form colonies after receiving definite doses of radiation can be expressed by a similar graph.

The curve shows that the amount of effect differs greatly among similar individuals. Some are killed or injured by small doses while others remain alive even after heavy doses. This is because they differ in sensitiveness to radiations as well as to all other injurious agents. It is also apparent that the results of repeated tests made under exactly corresponding conditions are by no means identical. Differences always occur, but in favorable material they are not great as the results shown in Figure 1 indicate.

<sup>1</sup> Presented before the Radiological Society of North America at the Twenty-first Annual Meeting at Detroit Dec 2-6 1935.

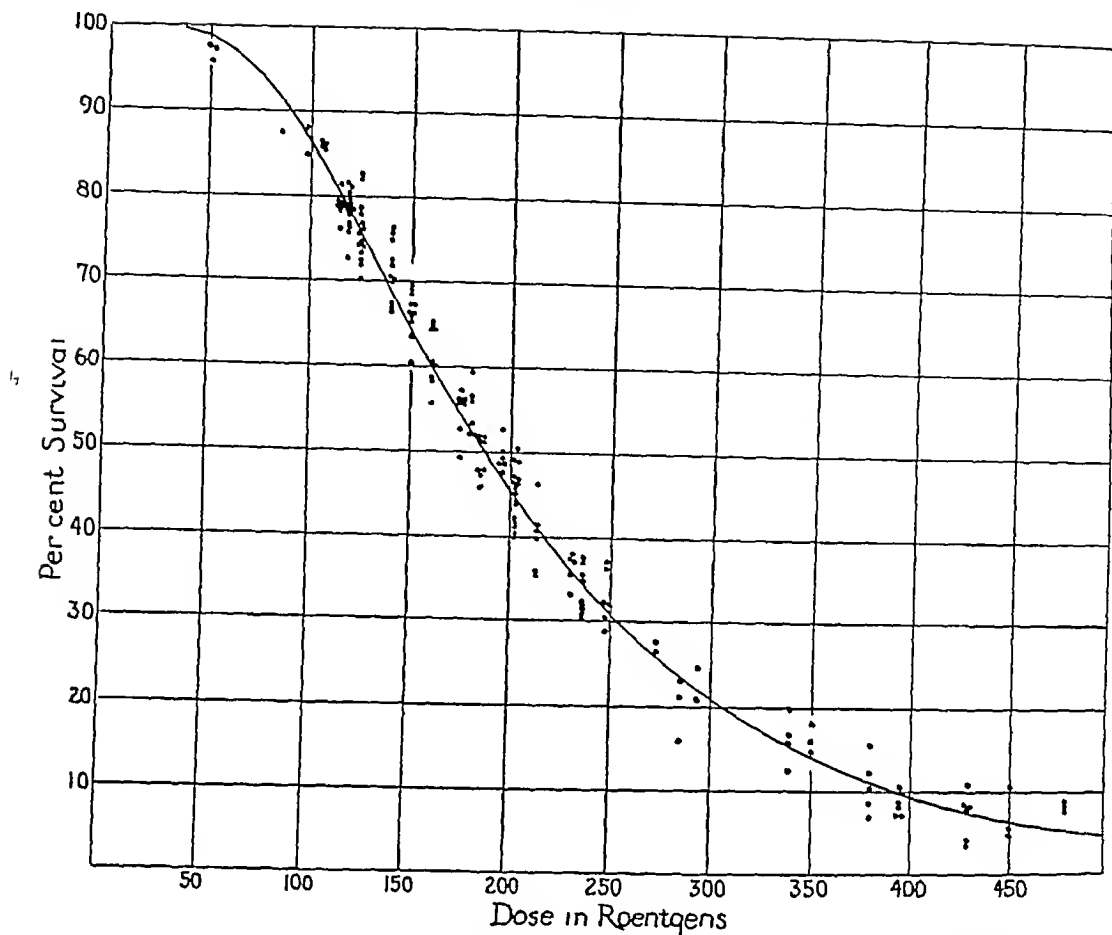


Fig 1 Graph demonstrating the precision of the *Drosophila* method. The results of 209 tests show the amount of variation which may be expected when the same doses are given to different samples of eggs.

In the tests from which these results were obtained, the potential used was 120 kv, the filtration being 0.25 mm Cu and 1 mm Al. Statistical analysis shows that the probable error of a single observation is  $\pm 3$  per cent. The maximum deviation is 7 per cent. These tests were made over a period of five years, during which time the stocks of wild flies which furnished the eggs were repeatedly changed, but the eggs have maintained the same average sensitiveness. Experiments made by others in this country and in Germany show that eggs from any stock of these wild flies are nearly alike in their response to x-rays (5). In this respect they are superior to the usual dosimeters, which must occasionally be recalibrated.

So constant and dependable is their response that it can be used as a measure

of dosage. Thus, if half of the eggs survive after receiving about 190 roentgens, it is also true that when this proportion survives after an exposure to an unmeasured dose, the eggs must have received about 190 roentgens. So, also, if any other percentage of survivors is obtained, the dose which was given can be determined with considerable accuracy by reading from the curve the number of roentgens corresponding to that percentage.

It has been customary, when recording survival percentages obtained in tests with *Drosophila* eggs, to note the dose in roentgens, as measured in this way. The number thus obtained is called the "biological dose," and is expressed in "biological roentgens." Strictly speaking, this use of the term "roentgen" is in-

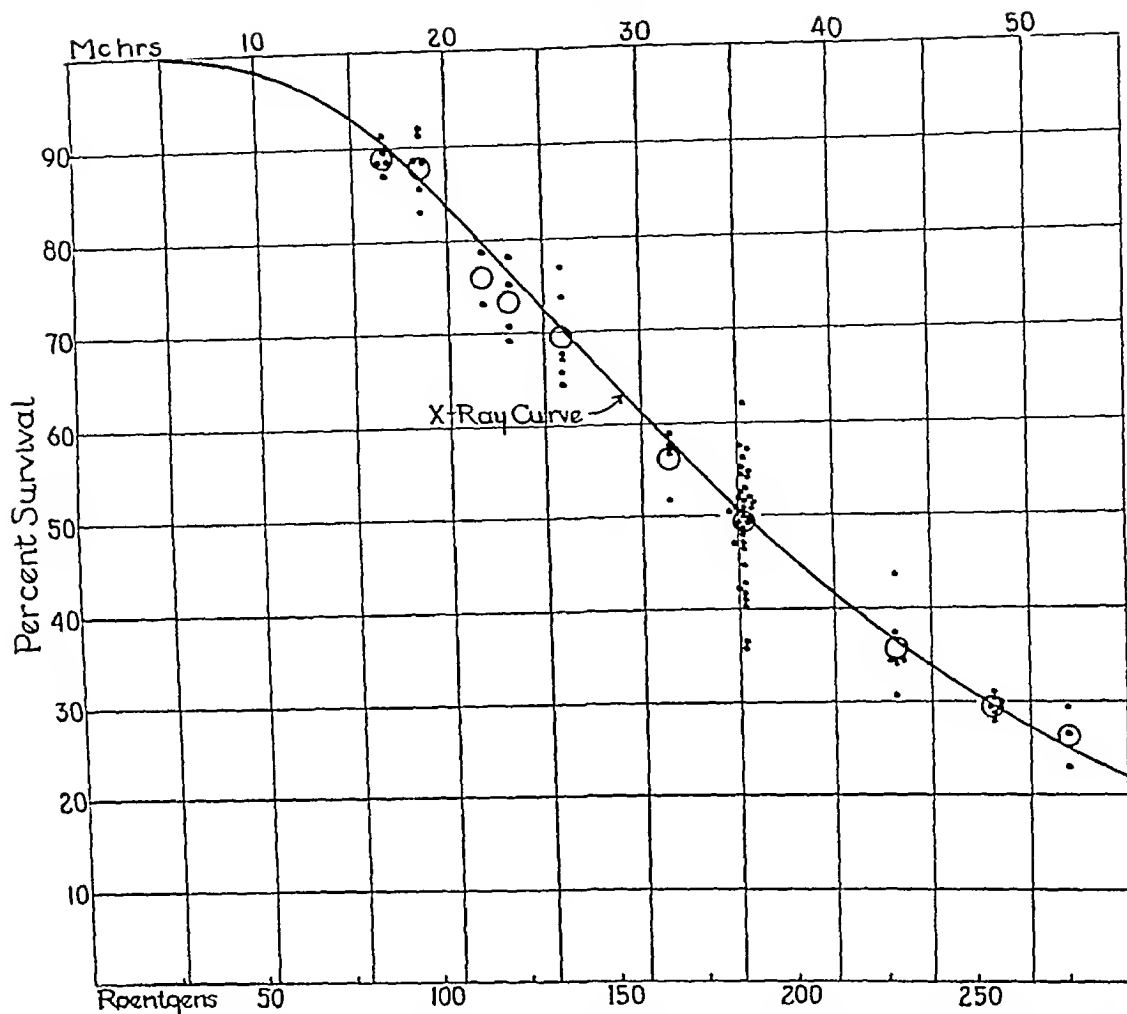


Fig 2 The measurement of gamma ray dosage in terms of biological roentgens. By superimposing the gamma ray survival curve on the x-ray curve the number of biological roentgens corresponding to one millicurie hour of gamma radiation (under the conditions specified) can be determined.

correct, but it is a convenient way to compare the magnitudes of the biological and physical doses. Obviously, in the series of experiments recorded in Figure 1 the two units are equivalent, but they are also equivalent over a wide range of wave lengths. Thus, in tests made with Grenz rays produced at 12 kv, the doses determined by the biological method and by the most careful open chamber methods agreed within 1 per cent (6), and at higher voltages they also agree, as will be shown presently.

But if the two units are equivalent why should the biological method be used at all, especially since it is time-consuming and requires care and experi-

ence in its use? Three experiments illustrate its value. First, it has been used in making depth dose measurements. More than ten years ago, Jungling (4) and Glocker (2) employed bean seedlings for this purpose. Recently, Hussey has used *Drosophila* larvæ as test objects for determining depth doses in paraffin, and I have employed the eggs of these flies in the measurement of depth doses in a water phantom. It is probable that the biological material responds to soft, scattered radiation which ordinary dosimeters fail to measure accurately. Thus the dose measured in biological roentgens may be greater than that measured by physical means, but the former more

correctly expresses the activity of the radiations at varying depths below the surface

A second application of the biological method of measurement is in the determination of the relation between wave length and biological effectiveness. The results of early experiments on this subject were contradictory because many times the biological conditions were not good, and because accurate physical measurement was impossible. But as these sources of error have gradually been eliminated, the results have become more and more concordant. Tests with *Drosophila* eggs show that equal doses of wave lengths produced at potentials between 12 and 550 kV result in equal quantitative data (6).

The same conclusion has been reached in tests with protozoa, wheat seeds, peas, beans, the eggs of *Ascaris*, of the green bottle fly, tumor tissue particles, and tissue culture preparations. Evidence from a very different source is presented by Timoféeff-Ressovsky, who shows that the number of mutations produced in *Drosophila* by radiations is independent of wave length, and is purely a function of the dose (7). In such cases, the dose, expressed in biological roentgens, is equal to that expressed in the physical unit.

In the third place, fly eggs or other suitable material can be used to measure the activity of gamma rays. Such an experiment is rendered difficult by the fact that the eggs must usually be exposed at very short distances from the source, and if an extended source, such as a tube or plaque, is employed, the intensity will not be uniform over the field occupied by the test objects. This difficulty has been avoided by Exner and Packard (1), who used an applicator in which highly concentrated radon was held in a bulb so small that it could be considered as a point source. This was enclosed in a spherical shell of Pt 0.5 mm in thickness, which served as a filter. Outside of the latter was a shell of bakelite, 4 mm in thickness, the surface of which was everywhere 1 cm from the source. The eggs

were placed on this surface. In such an applicator the standard conditions for the measurement of gamma rays are realized. The eggs were removed after they had received various doses measured in millicurie-hours. When the percentages of survivors were plotted in the usual way, the points were found to lie along the curve already obtained in the x-ray experiments (Fig 2). The course of this curve, therefore, is not affected by the wave length of the radiations used. It is now possible to determine directly the gamma-ray dose in terms of biological roentgens. For example, 50 per cent of the eggs survive an exposure of 38 millicurie-hours, but this proportion is found also after an exposure to 190 roentgens. The two doses are, therefore, equivalent in their biological effect under the conditions of this experiment. In other words, one millicurie-hour is equivalent to five biological roentgens.

This value is below that found by many physicists, who state that under the same conditions of filtration and distance, one millicurie-hour equals from eight to ten roentgens. The reason for this difference cannot now be stated with assurance, but it is probable that the values determined by physical methods may vary with the geometrical form of the thimble chambers employed, and that they may prove to be much too high. Another point to be considered is that, whereas the thimble chambers record the average intensity in a volume of air two or more millimeters in thickness, the eggs register the intensity at a point, since their diameter is a small fraction of one millimeter. This is important in view of the fact that the intensity of radiation changes very rapidly in the short distances which are used in these experiments.

The experiments with fruit fly eggs and other test objects show that it is possible to measure accurately the activity of x-rays and gamma rays in terms of the biological roentgen, and it is the biological activity of these rays which is the salient point in dosage.

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# THE RATE OF RECOVERY OF HUMAN SKIN FROM THE EFFECTS OF HARD OR SOFT ROENTGEN RAYS OR GAMMA RAYS<sup>1</sup>

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It is well known that a given quantity of radiation is better tolerated by human tissues if it is administered in small doses over a long period of time, than in a single dose or in a few large ones within a short time. The greater the fractionation, the more radiation can be delivered. This is obviously because in the intervals the tissues recover to a certain extent from the damage caused by the radiation. If this recuperation were the same for all tissues, there would be no advantage in dividing the dose, the normal tissues would tolerate more, but so would the diseased tissue. However, it has been found clinically that in many types of malignant tumors it is possible by dividing the doses to produce regression of the lesion without marked permanent damage to the normal tissues, whereas this was usually impossible with a single massive dose. This means that recuperation must proceed more rapidly in the normal than in the diseased tissues in such cases.

In some anatomical areas, the breaking down of the skin is one of the limiting factors to the amount of radiation which can be given. In others, the possibility of lymphedema and late necrosis of the deeper tissues will be the controlling factor in the amount and the method by which it is administered. It is important, however, to know how the skin behaves under different conditions of irradiation.

Since the beginning of divided dose methods, observations have been made on the amount of radiation tolerated by the skin under different schemes of treatment. However, the results obtained by different observers show wide discrepancies. In most of the published reports, the data

presented are completely inadequate to support the conclusions drawn, observations having been made on only a very few cases (four or five!). In some instances, results obtained with one set of conditions have been made the basis for conclusions regarding quite different types of radiation or schemes of fractionation. Elaborate methods of treatment have been developed on meager experimental data.

A review of the literature emphasizes the statements just made. It may be well to examine the data which have been most widely accepted.

Kingery (1), having observed that more radiation could be delivered if the dose was divided, realized that this must be due to recovery of some sort. He supposed that irradiation produced some hypothetical decomposition product in the tissues. The rate of loss of radiation effect would be in direct ratio to the elimination of this decomposition product. He assumed that this rate of loss would follow the same law as certain other chemical and biologic reactions, which could be represented by a logarithmic curve. *Note that he assumed a logarithmic curve, and then set about proving its existence.* Working with low voltage unfiltered roentgen rays, he found that a full dose could be repeated after 14 days. He does not specify what he means by a full dose, nor describe the effect produced, nor tell how he decided in favor of 14 days rather than—say—12 or 16. Nor does he specify the number of patients used in making the determination, nor give any idea of how the reactions differed among them. However, he went on to determine that 75 per cent of the full dose could be repeated after seven days, and 50 per cent after three and one-half days. On this basis it is reasonably assumed that the residual effects after three and one-half and seven

<sup>1</sup> Presented before the Radiological Society of North America at the Twenty-first Annual Meeting at Detroit, Dec 2-6, 1935.

days are 50 and 25 per cent, respectively. These results apparently verify the original assumption of logarithmic loss of radiation effect. The curve passing through the experimental points can be expressed by an exponential equation of the form

$$Q = Q_0 e^{-\mu t},$$

where  $Q_0$  is the initial dose of radiation,  $Q$  is the amount remaining after the time  $t$ ,  $e$  is the base of natural logarithms, and  $\mu$  an exponent which depends on the rate of recovery. Since it is known that half the effect is gone in three and one-half days, the equation becomes

$$50 = 100e^{-3.5\mu}$$

This may be solved for  $\mu$ , which is found to be 0.198. Putting this value for  $\mu$  in the first equation, the amount left at the end of one day is found to be 82 per cent, which corresponds to a loss of 18 per cent of the effect of the radiation during the first day. It is, therefore, assumed that if 18 per cent of the original dose is added daily, the tissue should be kept at the "saturation" point for radiation effect. With the quality of radiation and the type of treatment used, Kingery satisfied himself that this was true clinically. He apparently made no effort to test any other type of curve, any other daily factor, or find the limitations of his method.

Pfahler and Weatherwax (2, 3, and 4) have greatly extended Kingery's method and his conclusions, without, however, having done any actual experimental work. Based upon clinical experience as to when it is possible to repeat a full dose, for various qualities of radiation, values for  $\mu$  in the above equation have been worked out, and from these the daily loss for the types of radiation in question. Since it is not known what amount of radiation effect may still be present in the tissues when the dose can be safely repeated (say, 1 per cent or 10 per cent), and since the interval is stated in rather wide terms (from 8 to 12 weeks in a given type of radiation), it is evident that the value of  $\mu$ , and hence of the daily loss of radiation

effect, must have a rather wide range. However, a value of 6 per cent per day is accepted for 200 kv. x-rays filtered by 0.5 mm of copper, and it is assumed that the daily increment of this amount will maintain the tissues at a constant point as regards effective radiation. This hypothesis is based on the assumption that skin recovery must follow a simple exponential law.

This value of 6 per cent recovery in a day is very much less than that which has been found experimentally by any investigator, no matter how small his series of tests. Since, however, this factor is obtained from an entirely different type of observation than those about to be discussed, it is not surprising that they do not agree. This difference will be discussed later in the paper, in relation to the experimental results herein reported.<sup>2</sup>

The experimental data in the literature may be briefly reviewed. With the exception of Kingery's, already mentioned, they refer to radiation of the quality ordinarily used in deep therapy, namely, from 160 to 200 kv., and from 0.5 to 2.0 mm copper filter. The intensities used by various investigators ranged from 4 to 60 r per minute, but for any single experiment reported, the intensity was kept constant.

Fenzi (5) found by clinical tests on many patients that 200 per cent of a mild erythema dose, given in four equal doses spread three or four days apart, produced the same skin reaction as 100 per cent at one sitting.

Stenstrom and Mattick (6) treated two adjacent 10 X 15 cm areas on the breast in five cases of carcinoma. The upper always received 100 per cent of their erythema dose, and the lower 4 X 30 to 4 X 37.5 per cent, at about three-day intervals. The tabulated observations show wide variations in the results. Their conclusion that the data indicate a recovery

<sup>2</sup> Since the present paper was written, an article has appeared by Pfahler in which he states that, as a result of Reisner's work (herein discussed), he feels that the saturation dosage at any point or any day should be increased by 20 per cent (12).



ery of 8 per cent daily seems quite unjustified, yet this figure is often quoted

Liechti (7) used a more satisfactory method for making such a comparison. He irradiated on one thigh of each of 13 individuals, three small fields, with 60, 80, and 100 per cent of a sharp erythema dose. On the other thigh he used three separate exposures of 33.3 per cent, at different intervals, from 26 minutes to 96 hours. He found no difference between the single exposure and the divided doses for intervals less than 12 hours. For 24-hour intervals he found  $3 \times 33.3$  per cent equal to 85 per cent at one sitting, for 48-hour intervals to 75 per cent, for 72-hour intervals, to 60 per cent. *However, each of these findings is based on only two patients.* It is to be regretted that he did not complete a larger series of these tests.

Holfelder (8), using small ( $2 \times 2$  cm) fields on each thigh of six individuals, tested various divisions of irradiation based on Pfahler's saturation curves, and came to the conclusion that the recovery factors given were much too low, he did not, however, derive factors of his own.

Borak (9) treated three small series of patients with 180 r daily. Three cases were given  $10 \times 180$  r, and showed nothing, two cases with  $12 \times 180$  r showed strong pigmentation, one each with 15 and  $18 \times 180$  r had marked epidermitis. Since these three groups were treated for different lesions on different parts of the body, no conclusion seems justified from so few cases. If the groups had been larger, worth-while data would have been obtained.

It is apparent that all the reports thus far mentioned are based upon very scanty data, the literature contains others, drawing conclusions from even fewer cases. Since it is known that there are marked differences in the reactions of various individuals to radiation, it should be evident that before any conclusion can be reached it is necessary to make enough tests to obtain an average effect. Two such investigations have been published.

Reisner (10) made an extensive study of

erythema reactions, using an erythema meter to determine the intensity of the reaction, and following each test by daily observations over a period of several weeks. His standard reaction was a very sharp erythema, produced by 1,000 r (measured in air) on a field  $2 \times 2$  centimeters. Such a reaction is difficult to specify exactly. However, in every test, he plotted the daily observations as a curve, so that comparisons may be made on various bases. He used six small fields on each thigh. One field on every patient was given the standard dose, the others, various combinations, so that direct comparisons could be made. A considerable number of individuals were used, so that the final results represent adequate averages. With equal daily treatments, Reisner found the doses given in Table I to produce the same results.

TABLE I—VARIOUS FRACTIONAL DOSES WHICH PRODUCE THE SAME EFFECT IN HUMAN SKIN, ACCORDING TO REISNER

No Irradiations	No Roentgens per Irradiation	Total Roentgens	Percentage Total Dose
1	1,000	1,000	100
2	650	1,300	130
3	500	1,500	150
4	400	1,600	160
7	300	2,100	210
12	200	2,400	240
27	100	2,700	270

In order to find the shortest interval during which recovery could be shown, he used  $2 \times 50$  per cent on several fields, varying the interval between one and 12 hours. After four hours, the divided dose gave a less marked reaction.

The total dose which gave the standard effect in a given number of days could be given in equal daily doses, in doses twice as great given every second day, or three times as great given every third day, without producing marked differences in the reaction curves, although the final result was usually somewhat less marked with small daily doses.

Duffy, Arneson, and Voke (11), believing that the sharp erythema generally used as the standard reaction could not be deter-

mined as accurately as a threshold effect, and recognizing that many tests must be made in order to obtain average results, carried out an extensive series of tests on this basis. The reactions from two equal doses given at 24- or 48-hour intervals were compared with those from the standard single dose. Their fields were  $10 \times 10$  cm over the extensor surface of the forearm, their standard threshold dose, 525 r (measured in air) (This field, which seems rather large, was chosen because it was comparable with the fixed field irradiated by the four-gram radium element pack of the Memorial Hospital, since it was planned to compare reactions produced by the two types of radiation). They found the following doses to give the same final results

Single irradiation, 525 r = 100 per cent

Two irradiations, 24-hour interval,  $2 \times 400$  r = 150 per cent

Two irradiations, 48-hour interval,  $2 \times 425$  r = 160 per cent

They conclude that 69 per cent of the effect of the first exposure is lost in 24 hours, or 76 per cent in 48 hours. Their method of arriving at this figure is as follows. Of the first 400 r, enough must remain at the end of 24 hours to give, when added to the second 400 r, effectively 525 r, that is, 125 effective r<sup>3</sup> must be left. This implies that recovery from the effect of 400 r — 125 r or 275 r has taken place. Expressed numerically, recuperation equivalent to  $\frac{275}{400}$  or 69 per cent has occurred.

The same calculations applied to Reiser's data give 46 per cent in 24 hours. These two results are not in good agreement, but both are considerably higher

<sup>3</sup> The term effective r must not be interpreted to mean that any number of roentgens of radiation actually remain in the tissues. The above calculations do not in any sense imply a decay of radiation analogous to the decay of radon. At present there is no information regarding the mechanism of the action of radiation on tissues which is applicable to this problem. It can only be said that the radiation acts as if there were a certain amount remaining at any specified time.

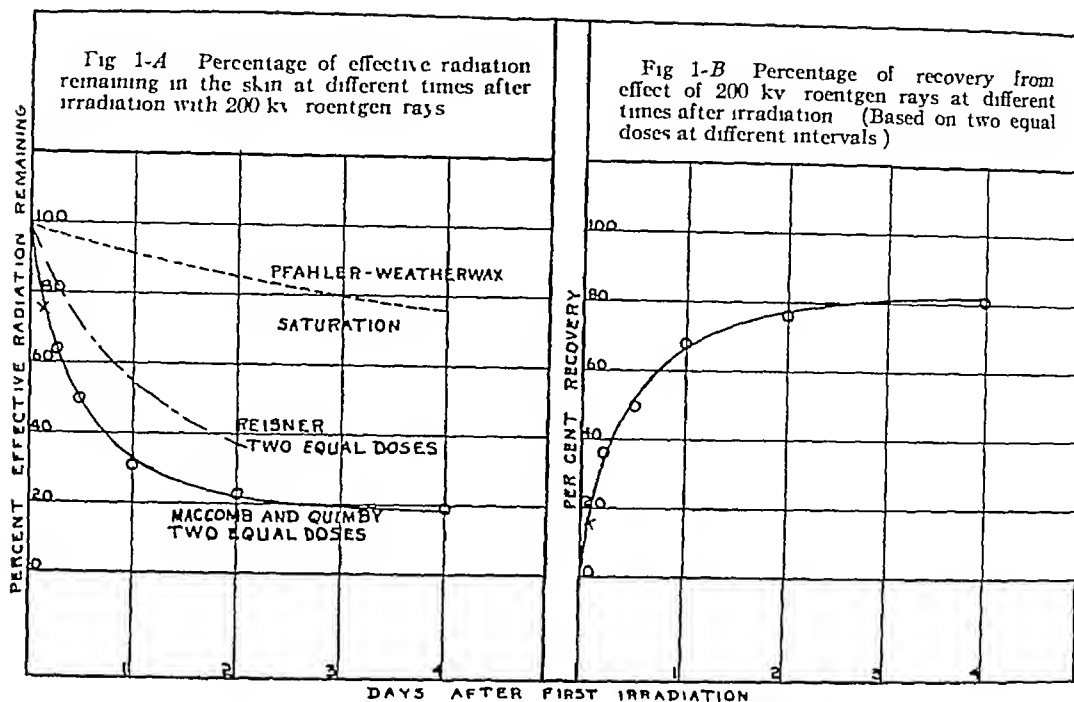
than the "saturation" values. Since Reiser's observations were made on a very sharp erythema, and Duffy, Arneson, and Voke's on a threshold, it is not surprising that the results do not agree. It might be expected that there would be greater recovery in the case of the smaller original dose.

The method of Duffy *et al* seems to offer the best means for obtaining accurate information, even though it be granted that, in general, therapeutic irradiations produce sharper reactions. It was felt desirable to extend their work to other divisions of irradiation and to other qualities of radiation. This has been done, and the results are here presented.

The hard x-rays used were exactly the same as those of Duffy and his co-workers: 200 kv (peak), 0.5 mm copper filter, 50 cm target-skin distance, about 60 r per minute. All doses stated are measured in air. The fields used were  $10 \times 10$  cm over the extensor surface of the forearm of male patients, mostly from the intra-oral clinics of the hospital. Since the present authors had assisted in reading many of the erythemas in the earlier work, and expected that Dr. Duffy and Dr. Arneson would read some of the later ones, it was felt that the results of both series would be consistent, and that finally all the data could be handled together.

The threshold skin dose<sup>4</sup> for all x-ray tests is defined as that quantity of radiation which, delivered in one exposure, at the rate of from 40 to 60 r per minute, produces in 80 per cent of all patients a visible pigmentation within one month, and in the others no visible reaction. For gamma rays, the intensity of irradiation is much lower, and the time limit must be extended to six weeks, but the method of applying the test is the same.

<sup>4</sup> In former papers, this quantity of radiation has been referred to as the *threshold erythema dose*. This has given rise to some misunderstanding in other institutions, where different criteria of *erythema* are used. Since what is observed is not actually an erythema which may be transient but a pigmentation which persists for some time, it seems better to refer to this dose as the threshold pigmentation dose or simply the threshold skin dose.



The paper of Duffy *et al* presented results for 24- and 48-hour intervals. Longer and shorter ones have now been used, and the final results of the whole series are given in Table II. It is evident from this table that recovery sets in promptly, and at a rapid rate, half of the effect being lost in the first 12 hours. The recovery rate continually decreases, however, so that during the third and fourth days there is only 6 per cent more recovery than during the first two days.

It is of interest to plot these data on a curve to show the variation of loss of radiation effect with time after the first irradiation. This is done in the lowest curve of Figure 1-A. Each point on this curve represents the percentage of radiation remaining effective at the time indicated after its administration, as determined in the manner just described, the values being those of Column VII, Table II. They apply only to the case in which the radiation is administered in two equal doses, and when the individual doses are less than the standard threshold dose. The upper curve is based on the Pfahler-Weatherwax saturation scheme, with a

recuperation of 6 per cent daily for this type of radiation, the intermediate one is Reisner's, for 24- and 48-hour intervals. The two experimentally determined curves do not differ greatly, in comparison to the divergence of either from the Pfahler-Weatherwax curve. As has already been stated, the experimental ones are for different effects, and are obtained by different methods of observation.

The percentage of radiation effect lost during any period (or the percentage of tissue recovery) is obtained by subtracting from 100 per cent the values of the percentage remaining effective. These values for recovery are given in Column VI, and in the curve of Figure 1-B.

It is impossible to express the experimental data by a simple exponential curve. However, any curve may be expressed as the sum of exponential terms, in an equation of the type

$$Q = Q_0(ae^{-\mu_1 t} + be^{-\mu_2 t} + ce^{-\mu_3 t})$$

In this manner, curve (1) can be fairly well expressed by the equation

$$Q = Q_0(0.66e^{-1.6t} - 0.17e^{-0.52t} + 0.37e^{-0.14t})$$

TABLE II—RECUPERATION OF HUMAN SKIN AT DIFFERENT INTERVALS AFTER ROENTGEN IRRADIATION

I Interval Hours	II Total No Irrad	III r per Irrad	IV Total r	V Total Dose in Percentage of Stand Single Dose	VI Percentage Recovery during Interval	VII Percentage Remaining after Interval	VIII No. <sup>b</sup> Tests
	(1	525	525	100) <sup>a</sup>			65
6	2	320	640	122	36	64	16
12	2	350	700	133	50	50	27
(24	2	400	800	152	69	31	(65)
(48	2	425	850	162	76	24	(52)
96	2	440	880	168	81	19	8
24	3	275	825	157	(Compare 48 hours 162 per cent)		18
24	5	185	925	176	(Compare 96 hours, 168 per cent)		6

<sup>a</sup> This column indicates the total number of tests made to determine the tabulated data. It includes, of course, those which were too high or too low, as well as those which finally proved to be correct. Fewer tests were necessary in the present series because the very well established points of the first series made possible close approximations to the correct doses before the experiments were begun. Each point established makes subsequent ones easier.

<sup>b</sup> The value in parentheses are those determined by Duffy Arneson and Voke.

However, such an expression is of little value, for it is probable that experimental values for a larger number of days would not fall on the prolongation of the curve.<sup>7</sup>

There is no reason for thinking that the loss of radiation effect should follow a simple exponential curve. Kingery assumed a simple reaction product which he thought should follow a chemical law of mass action. But the action of radiation in producing tissue changes is obviously a complicated chain of chemical and biologic phenomena, and must be much better understood before there is any hope of reducing it to a mathematical formula.<sup>8</sup>

<sup>7</sup> The method of determining the coefficients and exponents in such an expression is too complicated to go into here. It is, however, based upon procedures which render extrapolation beyond the known points of little value.

<sup>8</sup> Since the present article has been written, an interesting theoretical discussion of a variable recovery factor by Hoffman and Reinhard has appeared (14). Using statistical methods, and considering an idealized slice of tissue, they develop expressions for the number of cells remaining undamaged and for those recovering from damage under various conditions of irradiation. For certain specified recovery factors for the first 24 hours including those of Stenstrom and Mattick (6) and of Duffy Arneson and Voke (11) they give sets of curves showing possible courses of recovery with different variations of this factor from day to day. So far they have considered only the two cases in which the recovery factor varies linearly and exponentially from the experimental work herein presented; it appears that for human skin neither of these is correct. The authors indicate that they expect to extend their treatment.

A complete dose of radiation is seldom given in two treatments, several are usually administered, at daily or longer intervals. In the lower part of Table II are shown the summations of daily dose to produce the same effect as a single full dose, in three or five daily irradiations.

For convenience in discussion, the various schemes of irradiation which lead to the same final result may be summarized as in Table III. It is interesting to observe that, according to these results, it makes very little difference into how many fractions the total dose is divided, so long as the total time remains the same. That is,  $2 \times 425$  r or 850 r, with a single 48-hour interval, and  $2 \times 275$  r, or 550 r, with two

TABLE III—RADIATION SCHEMES PRODUCING SAME FINAL RESULT IN SKIN

Roentgens per Treatment				Fri day	Total Roent- gens	Per Cent
Mon- day	Tues- day	Wednes- day	Thurs- day			
525					525	100
400	400				800	152
425		425			850	162
275	275	275			825	157
440				440	880	168
185	185	185	185	185	925	176

24-hour intervals, produced the same final result. This is also true for  $2 \times 440$ , or 880 r (96-hour interval) and  $5 \times 185$  r (four 24-hour intervals). In each of these pairs the difference between the two total doses is less than 5 per cent, which, as a

matter of fact, is in closer agreement than can be expected from this type of experimental work

Reisner found in similar experiments, in which the total time and total dose were larger, that he sometimes produced a more marked effect when he gave fewer stronger individual treatments. However, he shows curves for  $4 \times 60$  per cent in 12 days (1, 3, 7, 12 days) and for  $12 \times 20$  per cent in 12 days (daily), in which, after the thirtieth day the reactions follow the same course up to the fiftieth day, when observations were discontinued. Obviously they could not run parallel during the first two weeks of irradiation, but the final result is apparently the same.

Some radiologists insist that treatments must be given daily, or even twice daily. Yet if the good result obtained with daily irradiations can be duplicated by using treatments twice as large, given only every other day, the advantages to the patient and to the busy roentgen-ray department are obvious. Of course, the individual treatments must each be less than the threshold dose. The present experiment gives no information as to the recovery when the first dose is itself large enough to produce a visible reaction. Also there is as yet no information available as to the *relative recuperation of the skin and tumor tissue* under the various conditions, and it is only when this is known that one scheme can be definitely stated to be preferable.

The advocates of small daily doses often insist also on low intensity of radiation. In this connection another point may be brought out. From the curve of Figure 1 it would appear that in three hours, 25 per cent of the effect would be lost, 75 per cent remaining. (This point is indicated by a cross on the curve.) This shows that two treatments of 300 r each, separated by three hours, would produce the standard effect. This was not tested. However, in the course of another investigation, Dr Arneson and one of the present authors showed that, when the rate of administration of radiation, of the quality under consideration, was reduced from 60 r per

minute to 33 r per minute, the dose required to produce the threshold effect was increased from 525 r to 600 r (13). This required just three hours to administer. Therefore, it appears that, as far as the skin is concerned, *and for these short time intervals*, continuous irradiation produces the same result as the intermittent administration of two equal treatments, one at the beginning and the other at the end of the period, if the total dose is the same. This point should be investigated further, for it is of significance with regard to the question of the advisability of the use of high or low intensity in therapy. It suggests that the advocates of protracted, low intensity irradiation might obtain the same result by using high intensity doses at the beginning and the end of their customary irradiation periods.

It might be thought that the curve of Figure 1 could be used to calculate the residual amount from daily treatments for any time within its range. If  $5 \times 185$  r produce the same end-result as 525 r at one sitting, then the sum of the residuals on the fifth day from the five treatments ought to equal 525. That is, when the fifth irradiation is given, there should be left 32 per cent of the radiation administered the day before (one day recovery), 24 per cent of that given two days before, etc. When these values are tabulated, however, it is seen that this is not the case (Table IV). There is a discrepancy of 30 per cent, which is too much to be accounted for by experimental error.

TABLE IV—RECOVERY FROM SUCCESSIVE TREATMENTS, CALCULATED FROM CURVE

No Treatment	Time Elapsed Days	Per Cent Remaining (Curve)	Equivalent r (Per Cent $\times 185$ )
1	4	19	35
2	3	21	39
3	2	24	44
4	1	32	59
5	0	100	185
Total			362
Threshold Dose			525
Percentage of Discrepancy			30

It is evident that when daily treatments are given, recovery does not proceed as rapidly as indicated by this curve, which is

be obtained. The method of doing this can best be explained by reference to Figure 2. Consider first the dotted line

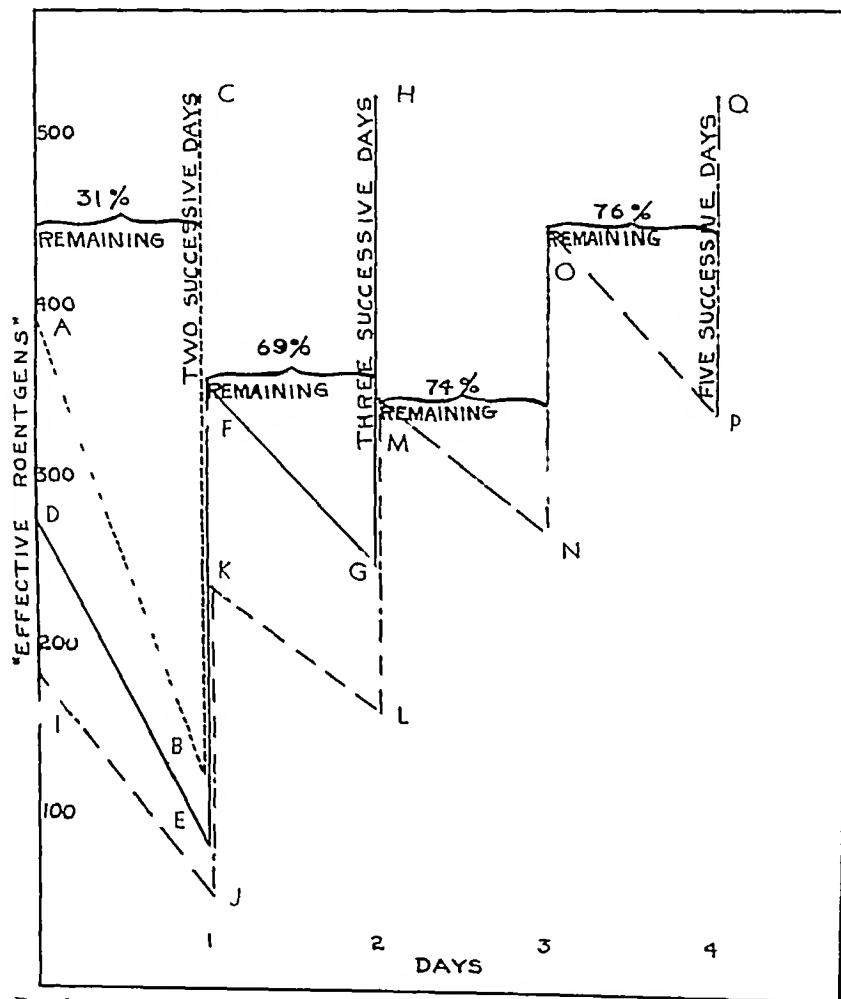


Fig 2 Accumulation of effect of 200 kv roentgen rays under various schemes of equal daily fractions (MacComb and Quimby)

based on the effect of only two treatments. One obvious explanation suggests itself. The values for various intervals in curve (1) refer to recuperation in previously unirradiated tissue. But when daily treatments are given, only the first is into tissue of that sort, for all subsequent ones the tissue has already undergone a certain amount of damage, and recovery would be expected to be less. Therefore, the only applicable factor in the above table is the one for the first treatment, all the others should be higher.

For special cases these higher factors can

starting at point A, or 400 r, this point represents the first dose of the amount necessary to produce the threshold effect when given in two portions with a 24-hour interval. It has been shown (see Table II or Fig 1), that 31 per cent of this is effective 24 hours later. This is indicated at point B, 125 r, or 31 per cent of 400 r. The addition of 400 r to this brings the curve to point C, the 525 r effective total.

It has been shown that three daily doses of 275 r each produce the same result. The solid line, starting at D (275 r), follows the course of this treatment

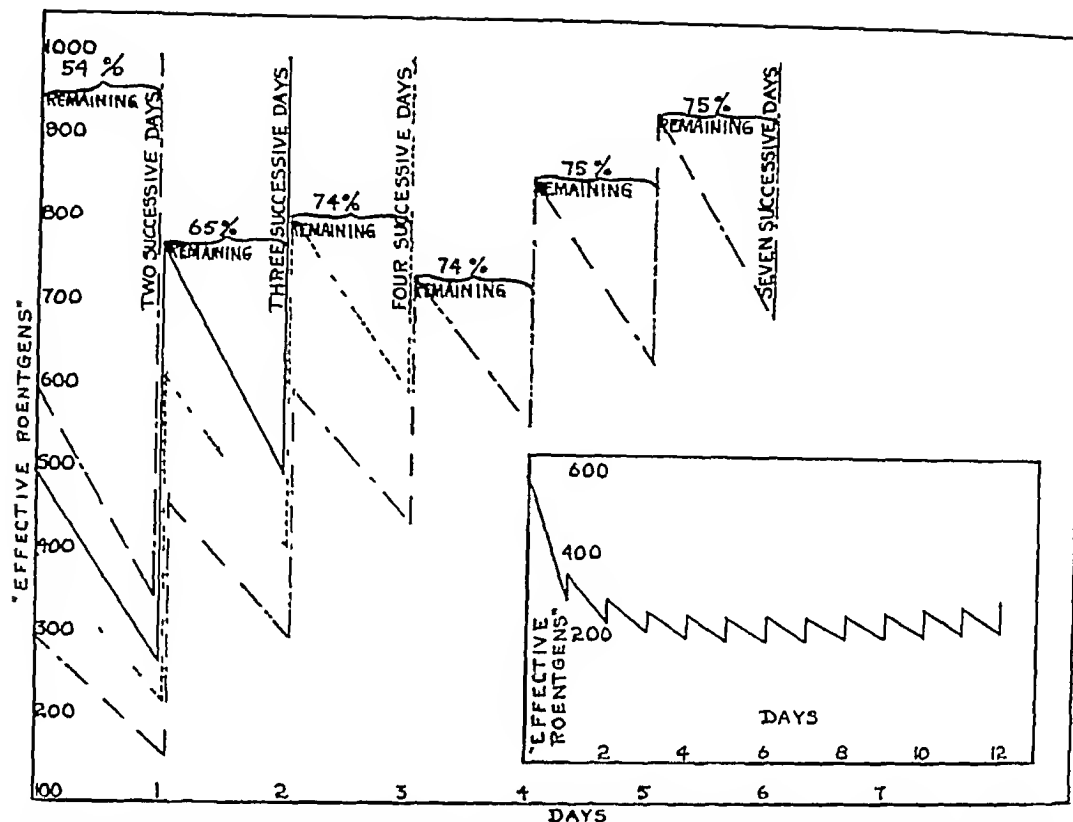


Fig 3 Accumulation of effect of 200 kv roentgen rays under various schemes of equal daily fractions (According to Reisner) Inset Application of these factors to saturation technique 600 r initial irradiation, plus 60 r daily

After 24 hours, 31 per cent of 275 r, or 85 r effective remain, indicated at point *E*. The second application of 275 r brings the curve to point *F*, 363 r. At the end of the second 24 hours it is not known as yet what part of this will remain, but it is known that another 275 r added to the remainder will produce an effective 525 r. This remainder, then, must be  $525 \text{ r} - 275 \text{ r} = 250 \text{ r}$ . That is, 250 r effective must be left from the 363 r, at the end of the second 24 hours. This is indicated by point *G*. Expressed in percentage remaining, it is  $\frac{250}{363}$ , or 69 per cent. To this

250 r effective, the third 275 r is added, bringing the total to 525 r. From this experiment it follows that, although 31 per cent of the effect remains after 24 hours in previously unirradiated tissue, 69 per cent remains after 24 hours when it is a second daily treatment.

The process may be carried on, by means of the five-day data, to find the amount remaining for every day up to the fifth. It is not necessary to trace it here step by step, the results are shown in the dashed curve *IJKLMNOPQR* (Fig 2). It appears that after two treatments the daily recovery does not change so rapidly, in fact, for the last two it is practically the same, 75 per cent effectively remaining, or the recovery being 25 per cent.

The present experiment offers no means of going further, but Reisner gives data for 7, 12, and 27 daily irradiations. The results of treating his data up to seven fractions in the same manner as the above give the curves of Figure 3. It is of great interest to note that, although his first-day recuperation is less than that found by Duffy and his co-workers, all subsequent ones agree with the values of Figure 2. In this connection it should be noted that,

for the irradiation in two treatments, Reisner's individual doses were greater than the single threshold dose of the pres-

number of treatments the 6 per cent figure would be approximately correct and "saturation" would be maintained But it

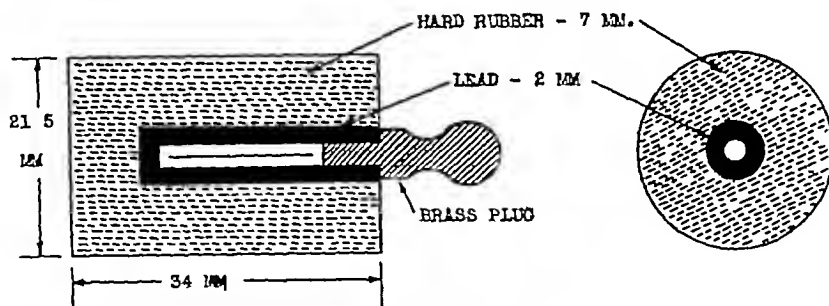


Fig 4 Applicator for determining gamma-ray skin doses The radon tube is kept at the center of the space by rolling paper tightly around it

ent authors When such a large initial irradiation is given, it should not be expected that recovery would be as great as for smaller ones For all other fractions, Reisner's doses fall below the threshold dose, and in these cases, values obtained from his data agree with those of the present work This is significant, for it shows that, even when the final reaction is a very sharp erythema, the recovery factors based on the threshold effect are applicable

It would obviously not be expected that 25 per cent recovery would go on indefinitely There is certainly a point in tissue damage from which there is no recuperation This point must be approached gradually When Reisner's data for 12 daily doses are treated as above, it is found that by the eleventh day there is only 15 per cent recovery By means of his 27-day treatment, it is calculated that after three weeks, daily recovery is less than 10 per cent

It is interesting in the light of this information to return to the "saturation" technic Here ordinarily an initial dose, approximately equal to, or only slightly less than, the threshold dose, is followed by small daily increments From Reisner's data it appears that recuperation from the initial dose should be of the order of 50 per cent, instead of the 6 per cent postulated by the users of this technic Successive doses would be recovered from less and less, until after a considerable

would be a saturation at a level of about half the threshold dose, or less, instead of being just below the full dose A curve representing this type of treatment is shown in the inset in Figure 3

No data are at present available for other intervals between irradiations

With respect to other qualities of radiation, experiments have been commenced with soft roentgen rays and gamma rays

The soft roentgen rays were generated at 100 kv peak, at about 50 r per minute, filtered by 1 mm of aluminum, the target-skin distance being 25 centimeters The same set-up for size and position of field was used as with the 200 kv radiation By a total of 60 tests, the threshold dose for this type of radiation was established as 185 r, measured in air<sup>9</sup> After 32 additional tests, it was found that the administration of 150 r on each of two successive days produced the same reaction This implies a recovery of 77 per cent in 24 hours, a figure somewhat greater than for 200 kv radiation

For gamma rays, tests were made with the small applicator shown in Figure 4, strapped to the skin in the same region as that used for the other experiments A total of 36 tests fixed the single exposure

<sup>9</sup> This value should not be quoted in any study of quality effect of radiation Large fields were used so that back-scatter plays an important part For the present study this is immaterial, since the question under investigation is recuperation for a particular type of radiation



for the threshold effect at 225 millicurie-hours, when the exposure time was between one and three hours. Twenty-eight additional tests established  $2 \times 160$  millicurie-hours as the corresponding dose for the 24-hour interval. This implies a recovery of 60 per cent, which is definitely less than for 200 kv roentgen rays.

In considering these other qualities of radiation, attention should be called to the varying periods during which it was necessary to follow the tests. The results of the low voltage roentgen-ray exposures could be determined within two weeks. The threshold pigmentation was first obtained after more than two weeks in only three of the 92 tests with radiation of this quality. The corresponding period for 200 kv roentgen rays is three weeks, only nine of the 257 tests becoming positive after this interval. With gamma rays, pigmentation may not appear until six weeks after exposure. In 10 of the 64 tests this was found to be the case, while in only 17 did it appear within two weeks. This points to some actual difference in the effects produced by the different types of radiation.

For the two types of roentgen rays, conditions of irradiation were practically the same as regards size of field and rate of administration. For gamma rays, both of these factors were different. The irradiated area was not sharply defined, but since the source was a tube 15 mm in length, placed 11 mm from the skin, the field was small. Also because of the short distance, the distribution of radiation in the thickness of tissue which is probably involved in the production of skin reaction was quite different from that for roentgen rays. The intensity was such that the time necessary for the production of the threshold effect was about fifteen times as great for gamma rays as for roentgen rays. All these factors may contribute toward making the gamma-ray effect different from that of roentgen rays, resulting in a different recovery factor. However, the fact remains that, for this type of radiation effect, the factor is different.

## SUMMARY AND CONCLUSIONS

A review of the data available in the literature on tissue recuperation after roentgen irradiation shows that very little systematic study of the problem has been made. Only two reports of detailed investigation were found, those of Reisner (10) and of Duffy, Arneson, and Voke (11). The work of the latter group, on the production of the threshold skin reaction by divided doses, seems to offer the most promising method for further research.

Following their technique, the amount of 200 kv roentgen radiation necessary to produce the threshold effect, when given in two equal doses, at intervals of from 6 to 96 hours, has been found, also the amount for three daily and five daily doses.

From these data have been calculated the recuperation from the first dose after any of the above intervals. Recovery is found to set in promptly, for even after six hours, 36 per cent of the effect has been lost, and after twelve hours, 50 per cent. It proceeds more and more slowly with longer intervals.

When more than two daily treatments are given, the above values can be applied only to the first, subsequent ones are recovered from more slowly. Values for these subsequent days are calculated and it is found that after the second day the change in recovery rate becomes less. From that time on, recovery proceeds at the rate of about 25 per cent daily to the fifth day, beyond which the data do not go.

Calculations made from the only other extensive data available, that of Reisner, confirm this value of about 25 per cent up to seven days, in spite of the fact that he used a much sharper reaction (1,000 r in air on a  $2 \times 2$  cm field, instead of 525 r on one of  $10 \times 10$  cm). This is particularly significant because it indicates that, even when the final result is a very sharp reaction, such as is obtained in clinical practice, recovery factors based on the threshold effect are applicable. For greater fractionation, with correspondingly greater protraction of the irradiation, the daily

recuperation becomes even less For daily treatments up to 12 days (20 per cent of the standard dose daily), the residual effect progresses slowly up to about 85 per cent, and for 27 days up to about 95 per cent

For soft roentgen rays and for gamma rays, the factor for the 24-hour recovery has been found, when radiation is administered in two equal doses For the soft roentgen rays, recuperation is greater than for hard, for gamma rays, it is definitely less

All the experimental results are consistent with clinical findings, no available clinical data are precise enough to permit the determination of numerical factors

The authors wish to thank Dr Duffy and Dr Arneson for their co-operation in this work They are particularly indebted to Dr Arneson for his assistance in making many of the gamma-ray tests They also wish to express their appreciation to Dr Failla for his interest and suggestions during the course of the work

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See

## FURTHER DEVELOPMENT IN SUPERVOLTAGE THERAPY APPARATUS<sup>1</sup>

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THIS paper is the continuation, and, to some extent, an enlargement, of a similar one presented elsewhere (7) on the same subject about two years ago. It deals in the first instance with the latest development of supervoltage roentgen therapy apparatus, but also considers briefly certain other medical possibilities of extremely high voltages. Whereas it may be said that the general principles of engineering design in the high voltage field have been laid down in a most satisfactory way from the beginning, during the past two years numerous technical detail developments have been added which make a review of the entire question of construction worth while.

### (A) SUPERVOLTAGE TECHNIC FOR THE PRODUCTION OF VERY HARD ROENTGEN RAYS (ACCELERATION OF ELECTRONS)

#### (a) *Emitting Source (Tube Design)*

(1) *Sealed Vacuum Tubes*—The development of sealed vacuum tubes for increasingly higher voltages has long formed a most intriguing problem of engineering research. From the point of view of therapeutic application, such a tube in appearance represents great simplicity of operation and hence is a most desirable instrument to the practical roentgenologist. However, the three following fundamental difficulties continue to place an upper limit to the engineering skill and ingenuity: the control of the cold cathode discharges, the screening off of the back diffusion electrons, and the assurance of a high vacuum. Through solution, in part or entirely, of some of these difficulties, the upper range of the sealed vacuum tube has been raised

during the last year to 400 kv constant (20 ma), and Gross (6) a few months ago made public the characteristics of such a tube in a very comprehensive manner. An ever-increasing number of installations is now making good use of this tube (Fig 1).

(2) *Tubes Operating with a Continuous Pump*—The above difficulties incited research also in another direction. It was thought that, by connecting the roentgen tube to a continuously evacuating pump, a sufficiently high vacuum could be obtained to insure satisfactory operation at increasingly higher voltages. In the beginning, mercury diffusion pumps were used but it was soon found that a liquid air trap had to be placed in the vacuum line between the last stage of the pump and the roentgen tube to remove the condensable mercury vapors collecting at normal temperature. Thus, then, although the pumping system was quite fast and efficient from the point of view of vacuum production, especially at higher voltages, had the drawback that a large amount of liquid air was consumed, entailing a great expense and considerable care to operate. In 1929, Burch (4) discovered that the method of evaporative distillation can be applied to some derivatives of petroleum, and that from these certain oils can be produced which have exceedingly low vapor pressure at atmospheric temperature. By using such apiezon oils in place of mercury in condensation pumps, a perfect vacuum was obtained without the introduction of a liquid air trap for the cooling of the vapor in the line. This represented a very great advantage, and Allibone and Bancroft (1) immediately undertook further experiments to apply the apiezon oil diffusion pump for the exhaustion of high voltage roentgen tubes.

<sup>1</sup> Presented before the Radiological Society of North America at the Twenty first Annual Meeting at Detroit Dec 2-6 1935

After a few changes, aiming especially to eliminate cracking of the oil, a diffusion pump has been developed which worked so satisfactorily that its use was proposed in

fore it appears superfluous to give a repetition of the same subject here. Suffice it to say that in the main they are unisectonal (Fig 3) or multisectonal (Fig 4), glass

XPT-4 X RAY TUBE

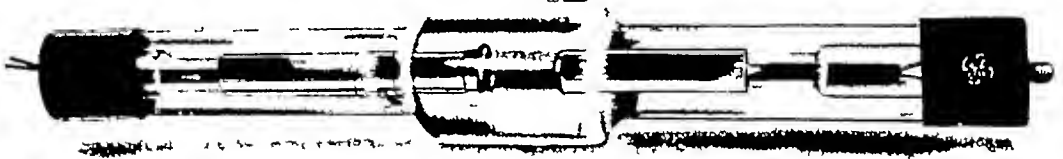
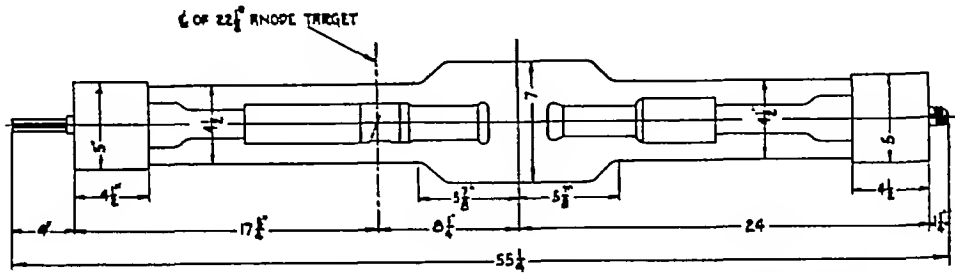


Fig 1 Sealed vacuum roentgen tube for 400 kv constant (20 ma) Above is a diagram of the tube below is a photograph of the tube (Courtesy of General Electric X ray Corporation)

preference to sealing of the tube, and, in 1934, Allibone and Bancroft were able to publish their results for the construction of continuously evacuated roentgen tubes (1) up to 250 kv D C (Fig 2), and Allibone, Beetlestone, and Innes for continuously evacuated thermionic rectifiers (2) up to 300 kv D C (Fig 5). The introduction of the apiezon oil pump represents a still greater advantage in the range above 400 kv, in that it permits a great simplification of operation with a considerable reduction in cost and an increased efficiency as compared to the old mercury diffusion pump.

The underlying principles of the supervoltage roentgen tubes operating on a continuous pump have been described in detail in our previous paper, and there-

walled or porcelain walled, anode-grounded or mid-grounded, constructed mostly for from 500 to 700 kv (equiv), and that a few actually run in the neighborhood of 1,000 kv. The changes which were made in these tubes more recently involve factors of lesser importance, mostly representing problems of technical detail. Mention may be made, however, of two types of tubes which incorporate rather unique arrangements. The first, the tube of Newell, Duveneck, and Hackney (8) is designed to operate on a continuous pump in the range of 400 kv. This tube is unisectonal, porcelain walled, and anode-grounded similar to the Lauritsen type of tube, but has two cathode filaments which are mounted 15 cm away from the target

at the end of a long steel pipe extending axially throughout the entire length of the tube. The target (water-cooled) is roof-shaped with two  $45^\circ$  gold surfaces,

potential which must be insulated between the two ends of the tube. The base of the porcelain assembly is supported by a stainless steel cylinder which projects

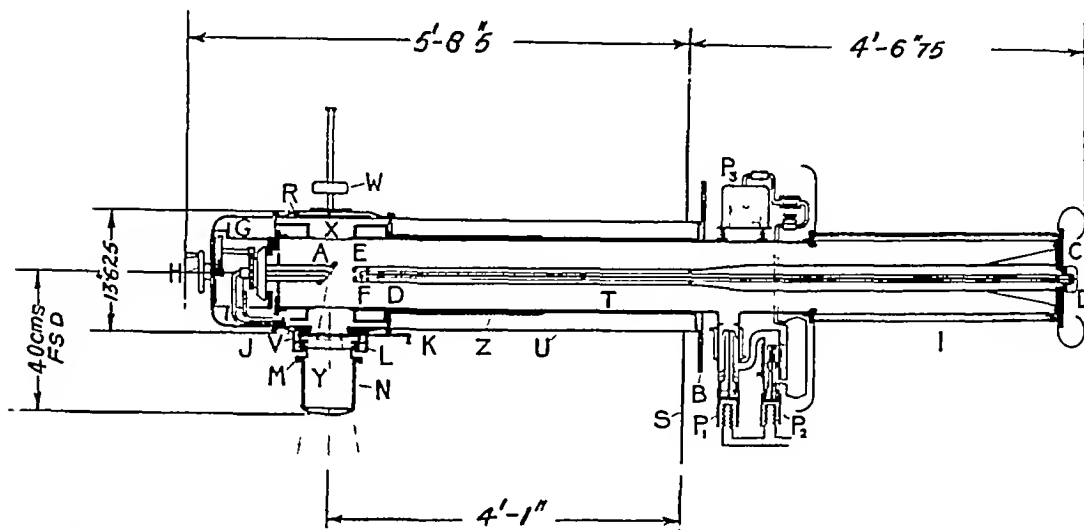


Fig 2 Continuously evacuated roentgen tube for 250 kv D C (Courtesy Metropolitan Vickers Electrical Company, Ltd)

permitting the use of the rays in various directions. Another feature is the fact that a valve is built into the tube itself, to make possible the use of a Villard potential doubling arrangement. The filament of the valve is set, at ground potential, into the brass cylinder of the anode end, just behind the wall, through which the cylinder projects into the treatment room, and the plate of the valve is represented by the cathode pipe. The second is the tube designed to operate with the direct current electrostatic generator of Van de Graaff in the range of 1,000,000 volts, 3 ma (Fig 6). Through the courtesy of Dr Richard Dresser of the Collis P Huntington Memorial Hospital we are able to give the following description, furnished through the kindness of Mr John G Trump of the Massachusetts Institute of Technology. The tube is of the cascade type made up of 15 porcelain sections, about 10 inches in diameter, and provided with diaphragms between sections, which serve to focus the electron stream in its passage from the upper end of the tube to the target, and also to break up the total

through the floor of the generator room into the treatment room, the whole arrangement being continuously evacuated by a high speed vacuum pumping system. The filament assembly is located on the upper end of the porcelain column, and will be provided with a total of 8 filaments so that replacement of the filaments will be necessitated only after eight of them successively have been burned out. A demountable water-cooled target at ground potential is attached to the bottom of the stainless steel cylinder. Both cylinder and target are surrounded by a suitable thickness of lead, and ports are provided on two sides and below the target, thereby permitting the treatment of three patients at one time, if desired.

#### (b) *Energizing Source (Generating Plant Construction)*

(1) *Induction Coil*—The use of this type of energizing source, which served as good a purpose in experimental pioneering for the introduction of supervoltage roentgen therapy as the old mercury interrupted Ruhmkorff coil served in the era of the

beginning of roentgenology as a whole, has now, at least for the time being, been discontinued

(2) *Transformer Circuits*—The most

An interesting and more recent development is the introduction of continuously evacuated thermionic rectifiers in the circuits (Fig 5) By doing this one may make

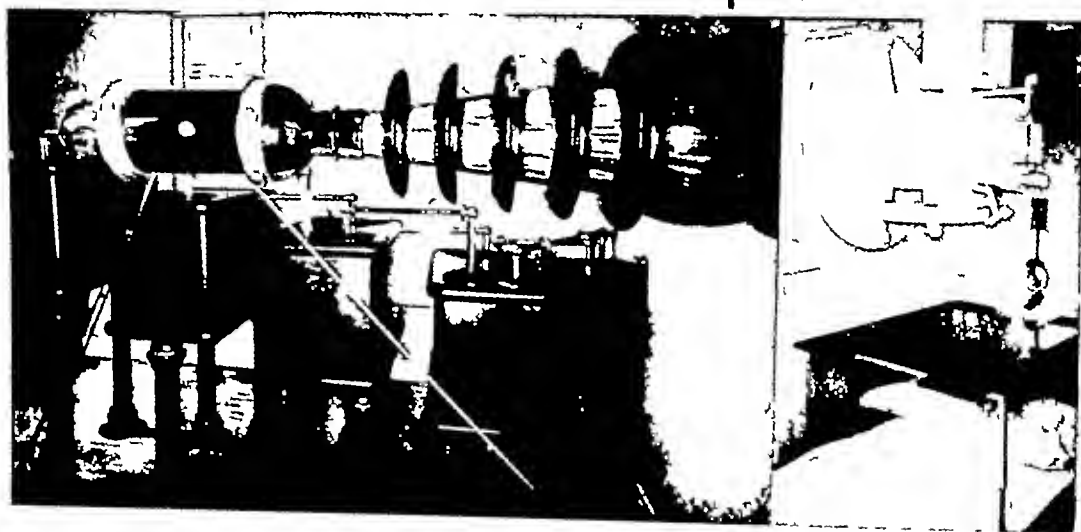
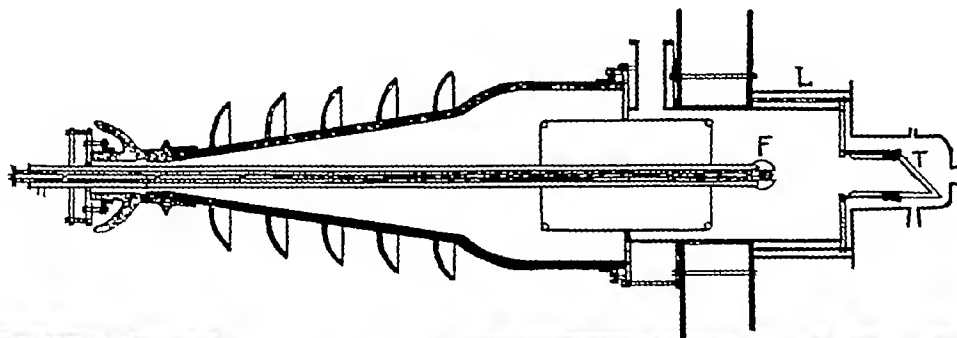


Fig 3 Unisectional porcelain-walled anode-grounded roentgen tube for 700 kv constant running on a continuous pump (Courtesy Kelley Koett Manufacturing Company)

commonly used circuits in the construction of high voltage generators are those of Latour or Greinacher, leading to direct current constant potential, of Villard, producing a pulsating potential current of Wittka, giving rise, likewise, to a pulsating potential current but with some flattening of the pulsation as compared to the Villard circuit and, finally, the straight alternating current whereby the tube is self-rectifying. Any of these circuits may be used in the supervoltage field in the form of cascaded systems or other suitable arrangements for the excitation of sealed vacuum roentgen tubes as well as continuously evacuated tubes operating with a pump

use of the half-wave circuit, or the rectifier may be applied advantageously to some of the fullwave circuits, making possible the construction of larger individual units which are then cascaded. In the half-wave circuits, the stray capacities between the rectifiers may be equalized in several ways, the Cockcroft (2) method, lending itself quite advantageously to the association with the continuously evacuated thermionic rectifiers. Through the courtesy of Dr Finzi and Mr Allibone, we are informed that a high voltage plant is under construction at Saint Bartholomew's Hospital, London, which will operate in the neighborhood of 1,000,000 volts, and which will make use of two 800,000

at the end of a long steel pipe extending axially throughout the entire length of the tube. The target (water-cooled) is roof-shaped with two  $45^\circ$  gold surfaces,

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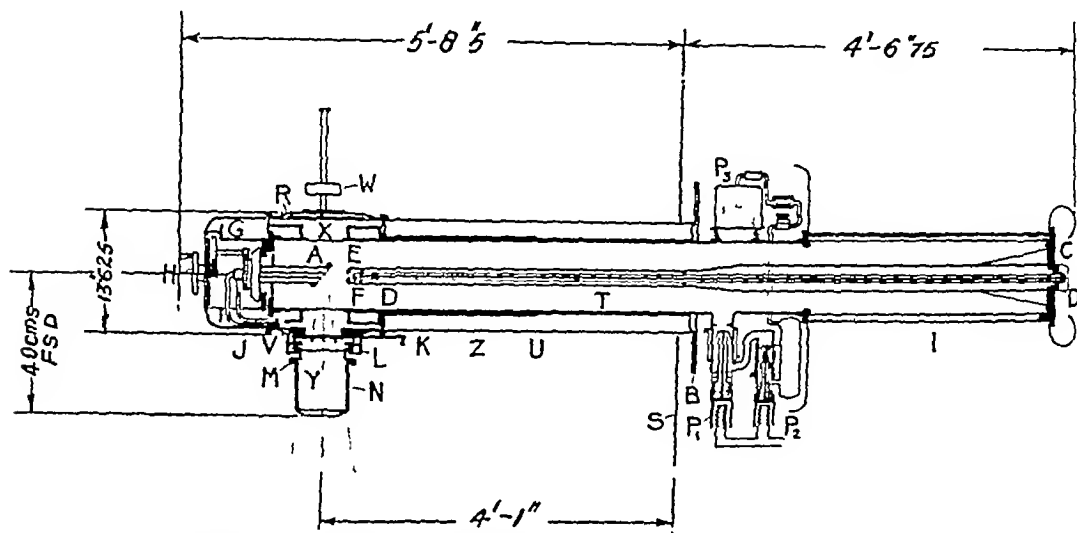


Fig 2 Continuously evacuated roentgen tube for 250 kv D C (Courtesy Metropolitan Vickers Electrical Company, Ltd)

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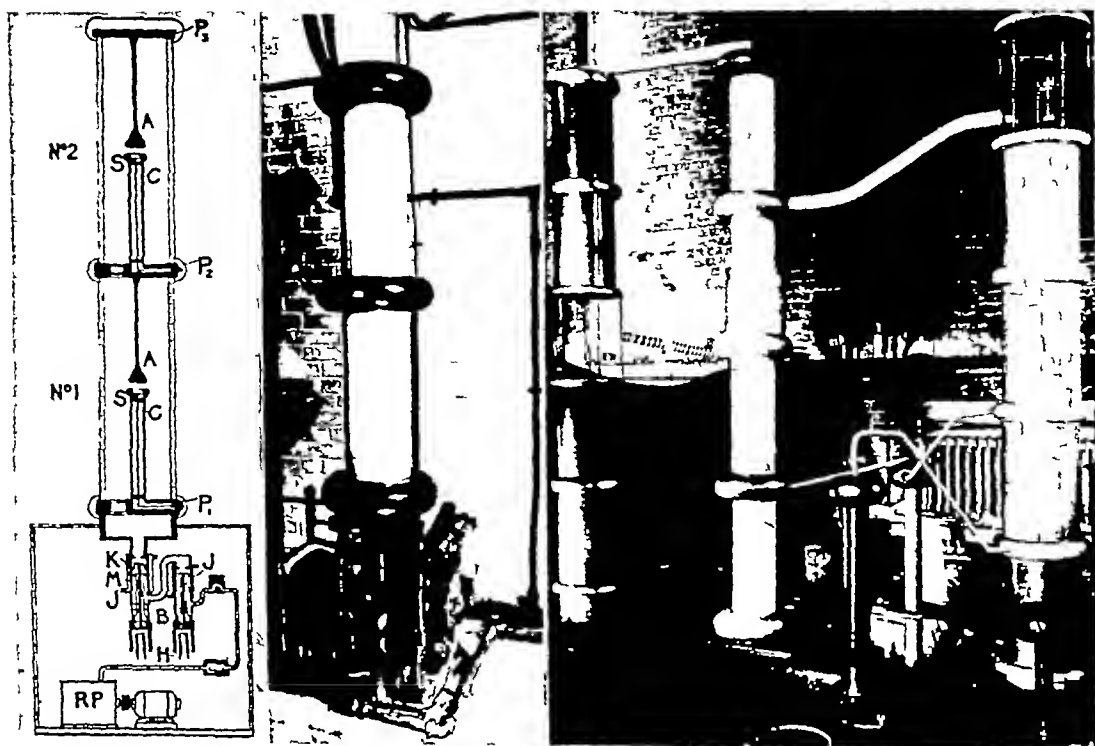


Fig 5 Continuously evacuated thermionic rectifier for 300 kv At the left may be seen a diagram and photograph of such a rectifier, at the right, its use in a Cockcroft circuit to give 600 kv D C (smooth) and 10 ma (Courtesy of Metropolitan-Vickers Electrical Company, Ltd)

(4) *Radio-oscillator High Voltage Roentgen Generator*—This apparatus, which was devised by Sloan (9), occupies a place entirely apart, since it produces roentgen rays at very high voltages by the use of a radio-frequency resonance transformer in a vacuum tank which serves at the same time as the roentgen tube. Such an installation has now successfully been used for a period of over one year in the range of about 800,000 volts for the medical treatment of patients. The construction of this apparatus, the general layout of the treatment unit, as well as the type and characteristics of the radiation obtained, were published in detail recently by Stone, Livingstone, Stanley, Sloan, and Chaffee (10).

A new suggestion, merely on a theoretical basis, was made in connection with doubling up the energy of electrons in such a type of roentgen outfit by Du Mond (5), who advocates a sort of magnetic reflection arrangement. According to Du

Mond's proposed technic, the electrons emitted from the high voltage terminal of the Tesla coil are accelerated into a field-free space, focused by a magnetic "lens" on a magnetic "mirror," then reflected back and refocused by the same magnetic lens on a target adjacent to the cathode and supported by the free end of the Tesla coil. It would be possible to obtain in this manner electrons impinging upon the target with an energy of 2,000,000 volts, the device thus permitting the generation of extremely hard roentgen rays. It must be stated, however, that the method has not as yet been tried out in practice.

(5) *High Voltage Impulse Generator with Multiple Acceleration on Transmission Lines*—Another method which is likewise in the experimental stage, but may be mentioned because of its medical possibility, is that of Beams and Snoddy (3). This method consists in accelerating the electron by an electric field which is so adjusted as to move with approximately



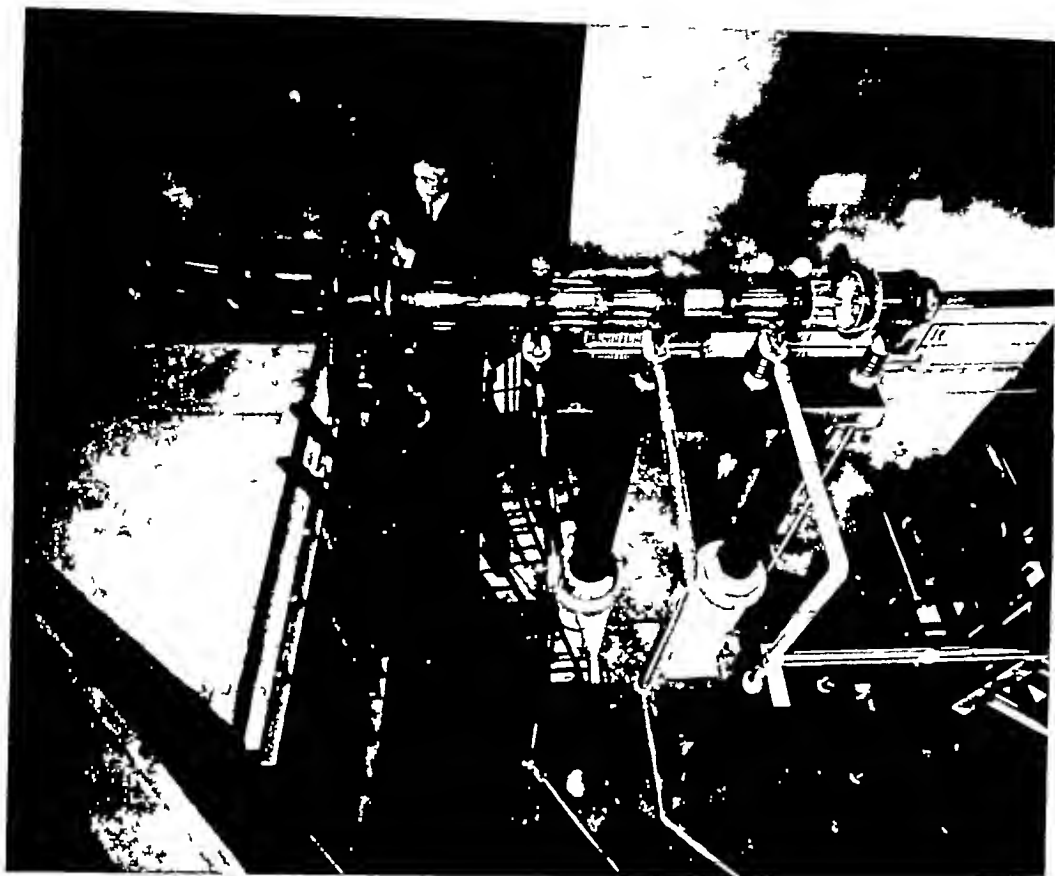


Fig 4 Multisectional glass walled anode grounded roentgen tube for 900 k.v pulsating, running on a continuous pump (Courtesy of General Electric X ray Corporation)

volt generators designed on the basis of the above principle (Fig 6)

(3) *Static Machine*—It is the merit of Van de Graaff (13) and his co-workers of having made possible the use of this type of generator for extremely high voltages. The machine which serves a good purpose in the field of nuclear physics (12) is now also being installed for medical use. Thus the high voltage group of the Massachusetts Institute of Technology is designing an apparatus for the Collis P Huntington Memorial Hospital, aimed to operate at 1,000,000 volts and 3 milliamperes. Again, through the courtesy of Dr Richard Dresser and the active co-operation of Mr John G Trump, we are able to give the following brief description of this apparatus (Fig 6). The source of high potential is a direct current electrostatic

generator of the belt type, which is equipped with current and voltage control so that the potential can be regulated over the full range from about 100,000 to 1,000,000 volts, the fluctuation being less than 2 per cent. The generator has six belts, each three feet wide and travelling with a speed of 5,000 feet per minute, which pass between the grounded base and the high voltage body. The ascending runs of the belts carry negative electricity to the high voltage body and the runs remove positive electricity from the high voltage body. The generator room is rectangular, having inside dimensions of 25 ft  $\times$  23 ft  $\times$  20 ft 6 inches. The walls and ceiling will be covered by a thin sheet of galvanized metal, so as to limit the influence of the high voltage body to the generator room itself.

paragraphs), or in a revolving manner by a system of multiple accelerations, according to Lawrence and Livingston (described in the former paper) Since that time the technical improvement has been of formidable proportions, and there are now a number of apparatus in actual use, some of them operating at voltages as high as ten million It would exceed the purpose of this paper to enter into a more detailed consideration of the development of apparatus of this sort Suffice it to say that the accelerated ions in the course of nuclear bombardment, for the prime purpose of which such apparatus are designed, give rise among other things to two phenomena which are of direct interest to medical investigation the production of neutron rays and the artificial radio-activity If both of these can be obtained in sufficiently large quantities for practical purposes, we may venture the following prediction concerning the possibility of their use

(1) The neutron rays may be applied directly, the same as other types of radiation, for the treatment of cancer Since they set free recoil protons from hydrogen, and since cancer, and the human tissues in general, are very rich in hydrogen, one can not conjecture enough about their therapeutic efficacy

(2) Radio-activated salts (as, for example, table salt) may be injected locally into cancerous growths or into the bloodstream for a more generalized effect

(3) Radio-activation may be produced in drugs with a more specific or more selective effect, permitting a radio-active influence limited to certain organs (liver, kidney, heart, etc) This sort of treatment may prove of greater value to other lesions than cancer

(4) Induced radio-activity in certain elements (Na, P, Fe, etc) may permit the study of the exact metabolism of these elements in the system by measuring with some very sensitive instrument (the Geiger counter) the distribution of the elements in various parts of the body in normal and pathologic conditions

There are probably other fields in which the use of neutron rays and artificial radio-activation may be of benefit, but which cannot be foreseen at the present time An apparatus for the purpose of the investigation of these medical problems is now being installed in the Radiologic Department of Harper Hospital, under the direction of Dr Evans and Dr Reynolds, and is nearing completion

### CONCLUSIONS

There can be little doubt that the use of increasingly higher voltages is making rapid headway in the medical field The apparatus used for practical roentgen therapy in the range above 200 kv are becoming standardized Where the new limits will lie is as yet difficult to estimate, but for the present it appears that the increase of voltage to from 400-600 kv (equiv) has, in certain instances, a decided advantage above the irradiation with 200 kv On the other hand, the introduction of the neutron rays and artificial radio-activity in the medical field may make the use of considerably higher voltages, or their equivalent energies necessary

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identical speed The discharge tube through which the electron moves is provided with short hollow cylindrical electrodes, each connected to a transmission

which are applied through an overvolted vacuum spark gap to the transmission lines These latter are adjusted so that the successive impulses arriving at the

1,000,000 VOLT 3 MA XRAY GENERATOR  
For Huntington Memorial Hospital

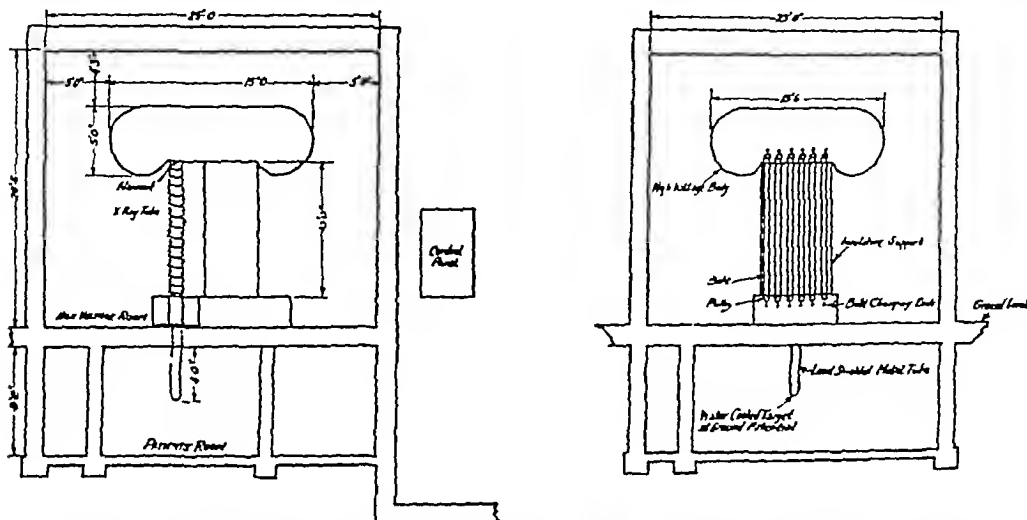


Fig 6 Diagram and plan of the Van de Graaff static machine to be installed at the Collis P Huntington Memorial Hospital, to operate at 1,000 kv and 3 ma (Courtesy of Dr Richard Dresser and Mr John G Trump)

line of increasing length but of very small "loading" or "tapering" The electric source is furnished by a Van de Graaff generator or Marx circuit in the form of surges or impulses, which are produced by the discharge between two metal spheres or more recently by an over-volted vacuum spark gap and which are applied simultaneously to all transmission lines In this manner, the electron moving with the approximate speed of the surge or impulse on the transmission line is continuously accelerated by passing through the successive pairs of electrodes The last apparatus which was published by Trotter and Beams (11) has seven transmission lines, the first terminating in a point wire, and the remaining one being connected to the successive electrodes mounted coaxially with the wire in an evacuated glass tube 4 meters long The electric source is constituted by a generator making use of the Marx (7) circuit, the impulses of

respective electrodes first pull electrons out of the pointed wire and then accelerate them between each pair of electrodes In this way, it was possible to obtain electrons of 2,500,000 volts maximum energy from a potential of 540,000 volts Marx circuit, which in turn was supplied with only 45,000 volts initial potential

#### (B) SUPERVOLTAGE TECHNIC FOR ACCELERATION OF IONS

In a manner similar to the acceleration of electrons, high voltage technic may be used also for the acceleration of ions Although such a procedure has nothing to do with roentgen therapy, it is incorporated briefly in this paper because of its possibility in the treatment of cancer and other medical lesions

It was brought out in our first paper two years ago that ions may be accelerated either in a straight forward fashion (by any of the methods described in the previous

# HEREDITY AND RADIATION<sup>1</sup>

By M. DEMEREC, *Cold Spring Harbor, N. Y.*

Carnegie Institution of Washington

It can hardly be doubted to-day that the laws of heredity, known as the Mendelian laws, are universal biologic laws. They have been found to hold true for all groups of living organisms which have been tested experimentally. These tests covered a wide range of organisms—in the animal kingdom: protozoa, molluscs, crustacea, insects, fishes, amphibia, reptiles, birds, and mammals, in the plant kingdom: bacteria, fungi, algæ, mosses, ferns, grasses, and a large number of orders of higher plants. Even though experimental breeding could not be carried out on human beings the statistical analysis of hereditary characteristics present in various families shows beyond any reasonable doubt that these laws apply to man as well.

One important point brought out in genetic experiments is the fact that the fundamental hereditary laws remain constant for all living organisms, thus making it possible to generalize the results of experimentation on any one organism and also to use for these tests the organisms best suited for experimental purposes.

Since the hereditary laws apply universally it is evident that the mechanism responsible for these laws must be identical for all organisms. I shall, therefore, begin this discussion with a brief review of what is known to-day about this mechanism.

The responsibility for the transmission of an hereditary characteristic can be definitely traced to a minute particle present in the germ-cell, called a gene. For example, a gene difference is responsible for a white or a red eye color in the vinegar fly (*Drosophila*), or for short *versus* long wings, cut *versus* whole wings, no wings *versus* the presence of wings, etc. We do not say, however, that there is a particular gene in

the germ-cell which determines the color of the eyes, another one which determines the size of the wings, still another, the shape of the wings, etc., *viz.*, that there is a gene in the germ-plasm for every organ or every characteristic of the organism. We know positively that this is not true. We know that the whole set of genes of an organism works as a unit and that it forms a balanced system which, together with the environment in which the organism develops, determines the appearance and the characteristics of the individual.

The total number of genes in an organism is large, in *Drosophila* it is estimated that there are between three to five thousand of them. If any change in a gene occurs, such a change is liable to upset the balance of the gene system and to have a detrimental effect upon the organism, which effect sometimes expresses itself as a definite morphological characteristic. That this balance of the gene system is a sensitive one is indicated by the fact that in a number of investigated cases in which either one or a very few genes were missing from a fertilized ovum, such deficiencies affected physiologic processes of the developing organism to the extent of being lethal. Detailed studies of certain of these deficiencies revealed that they have a lethal effect on even a small patch of cells which is surrounded by otherwise normal tissue. This indicates that genes perform very important functions, not only for the organism as a whole but also for every individual cell of that organism.

It is known that genes are ultramicroscopic particles, probably single organic molecules, that they are very stable, and that they possess the power of self-reproduction which is the most important property of living matter. Every cell of an organism possesses a large number of such particles—in the case of *Drosophila* over

<sup>1</sup> Presented before the Radiological Society of North America, at the Twenty first Annual Meeting, at Detroit Dec 2-6, 1935

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they have occurred, do not revert back. By increasing the dosage applied to a certain set of genes, therefore, the chances of a

concept is that changes in genes may occur in any cell of the organism, but only those affecting the reproductive cells will be

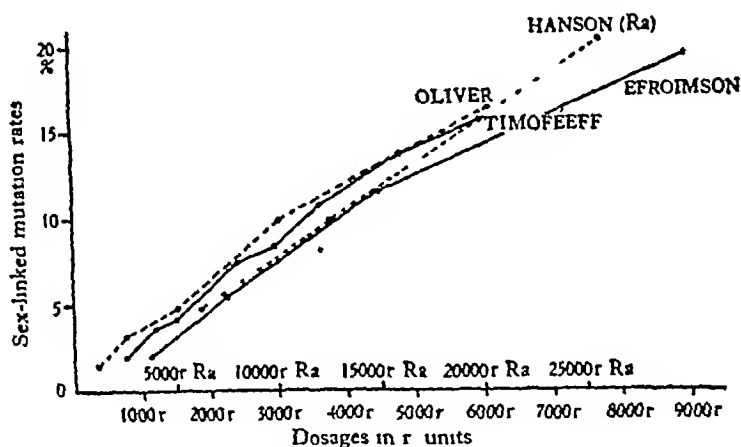


Fig 1 The proportionality of the rates of sex-linked mutations in *Drosophila melanogaster* to the dosages applied. X-ray experiments of Timoféeff Ressovsky, Efroumson and Schechtman and Oliver, and radium experiments of Hanson and Heys (From Timoféeff-Ressovsky, 1934)

gene being hit by an electron are increased irrespective of whether the increase in dosage is accomplished through a longer continuous or fractioned treatment.

X-rays are a very effective agent in producing hereditary changes. An application of about 2,000 r units increased the natural rate of gene change in *Drosophila* about one hundred times. In an experiment in which *Drosophila* sperm were treated with approximately 2,500 r units (Demerec and Lebedeff, 1935), out of one hundred sperm tested for  $\chi$ -chromosome changes, eighteen had lethal and visible gene changes and five had chromosomal rearrangements. Since the  $\chi$ -chromosome constitutes less than one-fifth of the total volume of the chromosomal set, these results indicate that more than one hereditary change per sperm should be expected from a 2,500 r unit treatment, if changes occur with equal frequency in other chromosomes. All of the changes observed, both genic and chromosomal, were detrimental to the organism.

As has been mentioned earlier, one of the basic concepts of genetics is that a full complement of genes is present in every cell of an organism. The logical sequel of this

transmitted to the offspring. It should be expected, therefore, that  $\chi$ -ray treatment of somatic cells would produce genic changes similar to those obtained from treating germ-cells. This is exactly what was found to happen. Patterson (1929)  $\chi$ -rayed eggs and larvae of *Drosophila*, and observed on adult males distinct patches showing the characteristics of genic changes. These patches varied in size according to the stage of development at which the treatment was applied. The treatment produced a change in a gene of a somatic cell and if it were given early in ontogeny, the cell with the changed gene divided many times, producing a large spot, but if the treatment were given late in ontogeny, the affected cell passed through a few divisions only, producing a small spot.

The effectiveness of  $\chi$ -ray radiation in producing hereditary changes has been demonstrated on a large enough group of organisms to make it certain that  $\chi$ -rays are generally effective in producing such changes. According to Timoféeff-Ressovsky (1934), the following organisms have been used in genetic radiation work: (a) Protista *Chlodon* (MacDougall), (b) plants

three thousand different ones, which perform a highly important function which in many instances is vital to the cell

Genes behave as highly stable entities. Although changes in genes do occur, they are very rare. There is ample evidence to show that genes are not affected by ordinary environmental factors, *viz*, that the ordinary environment is ineffective in producing hereditary changes. That does not necessarily mean that genes are chemically highly stable particles. It may indicate only that they are well protected by other components of the living cell. The only effective agencies in producing changes in genes are those which are able to reach the gene without injuring the cell. The most effective ones are  $\alpha$ -rays and related radiations, which invariably produce changes in genes (Muller and others). Ultraviolet rays are effective also, but because of their low penetration they can be applied only in specific cases (Altenburg, 1934). High temperature is the third environmental agent known to affect genes, however, it also can be used effectively only in special instances (Goldschmidt, 1929, Jollos, 1930, Plough and Ives, 1934, Buchmann and Timoféeff-Ressovsky, 1935).

Experimental evidence indicates that over 80 per cent of detectable changes in genes eliminate the gene (Demerec, 1933), *viz*, produce gene deficiencies. Such gene eliminations may be visualized as due to the loss of the reproductive power of the gene. Genes without reproductive capacity are automatically removed from the gene complex during the first cell division after such a change has occurred. As has been mentioned earlier, the great majority of gene deficiencies are highly detrimental to the organism. Viable gene changes also disturb the balance of the gene system and are likely to be detrimental to a greater or lesser degree.

The hereditary changes produced by  $\alpha$ -rays are of two types, *viz*, changes in genes and various chromosomal rearrangements. A large proportion of these chromosomal abnormalities coincide with detect-

able gene changes, so that the possibility is not excluded that both of them are due to the same cause, *viz*, that the chemical reaction, which takes place when a change in a gene occurs, affects adjacent chromosome threads in such a way that they fuse together and a rearrangement of sections occurs at the time when they break apart again (Demerec and Lebedeff, 1935).

The effect of the quality of radiation on the frequency of hereditary changes has been extensively tested by various workers (Efromson, 1931, Hanson and Heys, 1929, Stadler, 1931, Timoféeff-Ressovsky and Zimmer, 1935). Their results show conclusively that the quality of radiation, within the range tested (about 0.02 Å to about 2.10 Å), had no significant influence on the frequency of gene changes. It would be of theoretical interest from several standpoints to carry on these tests with still longer wave lengths and to make an exact comparison of the effects produced by ultraviolet rays and by  $\alpha$ -rays.

The results of numerous experiments on the relation between the dosage and the rate of gene changes show that the rate of changes increases proportionally with the dosage applied. Some of these experiments are summarized by Timoféeff-Ressovsky (1934) in the chart shown in Figure 1. The data indicate a simple relation between the electron hits and the changes produced in genes. This relationship is further indicated in the evidence obtained in fractional treatments. Patterson (1931) treated six sets of *Drosophila* males with 1,220 r units, one set was treated continuously and in the other five sets treatment was applied in eight fractions, the intervals between fractions being 24, 12, 8, 1 and 1/2 hours, respectively. Timoféeff-Ressovsky (1934) applied a dosage of 3,600 r units in six fractions spaced at 24-hour intervals. In neither of the experiments did fractioning have any influence on the induced mutation rate. These results show that there is no "recovery" in the case of hereditary effects and suggest that the electron hits produce changes in genes directly, since it is known that such changes, once

DISCUSSION OF SYMPOSIUM<sup>1</sup>

DR MILTON FRIEDMAN (New York City) Each one of this mornings' essayists has indicated discrepancies between his own results and those of the other speakers. Therefore, it is not too great a presumption to introduce clinical facts and variables which re-emphasize the difference in the biologic effect of varying wave lengths.

Firstly, x-ray burns are not infrequently followed by cancers, whereas, on a radium burn, they are relatively uncommon.

Secondly, it has been established by us and by others, that if a full erythema dose is given at one time with x-rays produced by 200 kilovolts, and filtered with 0.5 mm copper, the erythema will appear on the twelfth to the fourteenth day, whereas, if a single erythema dose is given at one time with a heavily filtered radium pack (in our case, 3 mm of platinum), the erythema will not appear until the fourth or sixth week and sometimes even later. This profound difference is frequently overlooked in comparing these various radiations.

At Bellevue Hospital we are now in our fourth year of comparing different wave lengths in the treatment of neoplasms of the mouth and throat, with protracted radiation—which protraction brings out the delicate differences between different types of radiations to a great extent—more so than single individual doses—and we too have learned, as Coutard originally stated, that x-rays filtered through 2 mm of copper are more effective than those filtered with 0.5 mm of copper. If the intensity factors are equal, the skin can tolerate more of the shorter wave length radiations, in a ratio of approximately eight to seven.

GIOACCHINO FAILLA, D Sc (New York) I just want to mention one point in con-

nection with Dr Friedman's discussion, because it may lead to serious consequences.

Dr Friedman mentioned that there have been no cases of cancer developing from over-dosage with radium. As a matter of fact, I know of some definite instances in which cancer has developed from radium burns in the hands of physicists and radiologists.

DR CHARLES B WARD (Seattle, Wash.) The skin reactions following the use of 800,000 volts x-ray, filtered through the equivalent of three millimeters of lead, have been very interesting. By using a divided dose technic we could occasionally give 5,000 r to a single port—we sometimes could go up to 6,000 r if we used a small port. This dosage produced no serious skin reactions on the neck but when the same amount of treatment was given over the jaw or antrum, the reaction was far too severe. A similar effect was noticed in treating a thin patient over the sacrum. This finding would tend to support Lauritsen's contention that the difference in distribution of secondaries is the main factor in minimizing the skin damage with super-voltage x-rays.

We also made tests for threshold erythema at various voltages and with filtration varying from five millimeters of copper to the equivalent of three millimeters of lead. We noted that as the filtration and voltage increased the time interval before the appearance of the skin pigmentation was also increased, and it was necessary to extend observations over a longer period of time. I believe that this delay in skin reaction is due to a difference in the quality of the radiation.

CHAIRMAN WOOD We might ask Dr Ward if he could give that supplementary information concerning the concrete and lead.

DR WARD Although I am no longer connected with the Swedish Hospital, I will be very glad to give you some preliminary data regarding the comparative protective value of concrete and lead.

<sup>1</sup> The papers of P. S. Henshaw, Ph.D., G. Failla, D.Sc., Prof. H. Holthausen, M.D., L. S. Taylor, Ph.D., and S. G. Mudd, M.D., with C. K. Emery, M.D., and R. S. Harrison, M.D., have not been received for publication.



Nucoraceæ, Sporobolomuces, Nadsonia (Nadson and Philipov), wheat (Stadler, Sapchin, Delanny), oats (Stadler), barley (Stadler), rye (Levitsky, Navashin), *Hyacinthum* (de Mol), *Nicotiana* (Goodspeed), *Datura* (Blakeslee), tomatoes (Lindstrom), *Mirabilis* (Brittingham) and *Antirrhinum* (Stubbs), (c) animals *Apotele* (Nabours), *Bombyx* (Astaurov), *Habrobracon* (Whiting), *Drosophila melanogaster* (Muller and others), *D. funebris* (Timoféeff-Ressovsky), *D. pseudo-obscura* (Schultz), *D. virilis* (Demerec, Fujii), *Macrosiphum* (Pirocchi), and mice (Dobrovolskaia-Zavadskaja, Snell)

I shall conclude this presentation by expressing a geneticist's opinion concerning x-ray treatment of human beings. A geneticist would not oppose treatment applied to somatic tissues. It is true that such treatment produces genetic changes similar to those produced by the treatment of germ-cells, but it is very likely that the organism will take care of detrimental genetic changes produced by it. In the treatments of somatic tissues, however, difficulties might arise if the application is given to fast-growing tissues or to embryos. In these cases cells possessing induced detrimental genetic changes might multiply and develop into sectors of abnormal tissue with a possible detrimental effect to the individual. A geneticist, however, would strongly oppose the treatment of any cells which would develop into functioning germ-cells. Experimental research has positive evidence to show that such treatment increases the frequency of hereditary abnormalities. Some of these can be expected to be so great as to produce abnormal embryos which would be eliminated before birth, others would develop into abnormalities which would show up on the offspring of treated individuals, the majority of these abnormalities, however,

would be recessive and would not appear in the first generation offspring, but would crop up in later generations if mating should bring together two germ-cells carrying similar abnormalities. A geneticist would not hesitate to predict that indiscriminate x-ray treatment of germ-cells will increase the number of carriers of detrimental hereditary characteristics in any race in which that treatment is practised, and if continued long enough, will have a grave detrimental effect on the race as a whole.

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the bulk of the cell mass there are as a rule scattered clumps of cells which, as judged by their staining characteristics, appear viable, although there is definite evidence of severe damage

No attempt has been made to measure depth dose since we believe the measurement of depth dose is as yet impractical. It is our purpose to produce the best quality of radiation possible, by high voltage and dense filtration, with adequate focal skin distance, and deliver sufficient radiation to cause a favorable reaction

Whether the improvement in results is due to the quality or quantity of radiation delivered to the tumor is undetermined and is, I think, a problem for the future

I have a few lantern slides which show some developments made on higher voltage apparatus at the Lincoln General Cancer Clinic by T. R. Folsom, in charge of the Department of Physics

*First* Our measurements are made by a large open air chamber placed on the outside of the treatment room and protected by a two-foot wall of concrete. A small beam of x-ray is allowed to pass through a lead gate in the wall to the air chamber. Through a tunnel on the opposite side it escapes into the ground, thus avoiding any back-scattering. The position of the standard air chamber is approximately eight feet from the focal spot of the tube

*Second* Dr. Leucutia has brought out some points concerning vacuum pumps. In the beginning we used mercury vapor pumps similar to those described by Dr. Leucutia. They were a constant source of trouble and expense. After a few months of unsatisfactory experience, Mr. Folsom built our first set of apazine oil pumps, these were located about twelve feet from the tube. Several attempts were made to obtain satisfactory operation but it was not until a new set of pumps were located only a few inches from the tube proper that we were able to get satisfactory and rapid evacuation

*Third* The x-ray tube, in the beginning, was similar to that used by Dr. Leucutia, end ground and one stage. We experi-

enced considerable difficulty operating over 400 kv. For this reason the tube was rebuilt into a two-stage affair, which permits operating at capacity

About this time the small one and one-quarter inch gold target was abandoned. Mr. Folsom substituted a target three and one-half inches in diameter, constructed of  $\frac{1}{100}$  inch pure lead on a copper backing. This has not only reduced the replacement cost from \$40.00 to \$0.50 but has increased our efficiency output and quality of radiation

*Fourth* The entire end of the tube has been remodeled and for the brass water jacket, one of aluminum has been substituted. This change has been of the greatest advantage in equalizing the quantity and quality of all four ports. The output from each is now not only equal in volume but equal in quality as well

*Fifth* The cone construction has also been changed. We have installed cones of one-half inch lead, lined with aluminum, with a rotating cap, which permits selecting any sized opening at any desired angle

An electric light bulb has been placed in the extreme apex of the cone, the light permitting the operator to determine the exact location, size, and shape of the area to be treated. There has been (and justly so) criticism on the difficulty encountered in securing proper positions with a fixed tube. We find with our present setup that it is sometimes difficult to secure correct areas. The light, however, assists us materially and affords an accurate means of determining the tissue which will receive radiation

The voltage referred to in the above discussion was checked on each individual transformer, later by the large sphere gap and again by the electro-static constant reading voltmeter. Needless to say, these measurements may be in error and are subject to future correction

DR. HENRY SCHMITZ (Chicago) [The Editor wishes to state that Dr. Schmitz wished to combine the discussion he presented in this sequence with his paper, the latter to be published at once (March, 1936,

Three years ago I was in Brussels. They have a very large supply of radium on hand in a lead-covered safe. This safe is placed in a room which has concrete walls one meter in thickness, and you enter this room through a winding passage.

Some months later we went over the General Electric specifications for the 800 kv tube and found that they called for three inches of lead in the floor of the treatment room, two inches in the side walls, and partial leading of the control room and transformer room. I suggested concrete as a substitute. Some tests were made at Memorial Hospital and we finally decided to use three feet of concrete in the floor of the treatment room instead of three inches of lead, thirty inches of concrete in the walls of the room instead of two inches of lead.

After treatments were started, dental films were placed in various parts of the building for two weeks at a time. No fogging could be detected under the floor or outside the walls of the treatment room. These tests were repeated several times. At the present time Mr. J. E. Rose, the physicist at the Swedish Hospital, is making very complete tests which will be published in the next few months. He tells me that three feet of concrete is many times as efficient as three inches of lead. If any of you are considering such an installation, I am sure that you can feel safe in using concrete. Mr. Rose's data will be available at the Bureau of Standards in a very short time.

DR. ROSCOE L. SMITH (Lincoln, Nebr.) I first adopted the use of voltages higher than 200 kv in the Summer of 1933. Since that time 350 tumors have been treated, either by supervoltage alone or in combination with radium and surgery. Prior to 1933, I used a similar combination with 200 kv. Certain observations as to the effect of higher voltages must, therefore, be compared with my previous experience, using the same combinations but with lower voltages.

higher voltages the filtration and voltage have been increased from time to time, each step showing some improvement in the various effects that I will mention, the best effect occurring during our last and present setup.

72 cm distance	plus	3 mm steel
2 2 mm lead filter	original	3 mm Al
0 5 mm copper	filter	9 mm water
0 25 mm block tin	in tube	
3 mm celluloid		

700 kv C P electro-static voltmeter reading  
Output, 15 r per min  
Daily dose, 300 r  
Total to one skin field 2,000 to 3 000 r through multiple skin fields

Although the subject is open to controversy it is my opinion that supervoltage radiation is superior to 200 kv radiation for the following reasons:

(1) Pre-operative radiation of this type is of great advantage on early cases and surpasses other palliative measures on incurable lesions.

(2) More rapid tumor regression is noted.

(3) There is rapid relief of pain.

(4) Radiation sickness and skin erythemas are absent.

(5) Blood changes are less severe.

(6) The general condition of the patient improves more rapidly and the improvement is more apt to be permanent.

(7) In my experience long protracted treatments of supervoltage are most desirable.

(8) A combination of extremely high voltage radiation and one-third of an erythema dose of lower voltage treatment seems to produce more rapid recessions on diffuse, superficial lesions.

(9) The effect on neoplasms closely resembles the changes produced by interstitial radium radiation. It is not uncommon to observe in sections of previously irradiated tumor tissue a complete destruction of the nucleus where only the cell walls remain visible. In others there is a varying degree of pycnosis and the cytoplasm is distended with a clear, pale staining substance. Many times the cytoplasm becomes granular and there is marked karyorrhexis. Even when such damage occurs to

DR COSTOLOW Our dosages are all measured by the same method used at California Institute of Technology—with the standard air chamber, the output in air being measured each morning

DR JOHN T MURPHY (Toledo, Ohio) We have heard much this afternoon about the supervoltage from 550,000 volts to 800,000 volts What I have to say will be based on 400 kilovolts of pulsating current

The reason I adopted this machine was twofold I could not afford a larger one and I thought somebody should try middle-volt radiation rather than the so-called supervoltage

The factors I am using are 400 kilovolts pulsating current, 80 centimeters distance, filter, 2 millimeters of copper built into the tube and an additional Thoreaus filter of one-quarter millimeter of copper, four-tenths of tin, one of aluminum The intensity varies with the tubes from 14 to 16 r per minute

Of course, this machine has been in use for only eleven months and no final results can be told

I am surprised that the men using higher voltage and higher dosage on the pelvis have so few complications I cannot understand it because one of my great troubles is the care of the patient during the treatment from the mucositation produced in the bowel and other complicated effects both in the bladder and in the rectum Whether this is because of a difference in biological effects, I do not know, but personally I have a great deal of trouble in controlling these elements

We have nausea, even though we never go beyond 210 r per day per field and one field per day We have weakness We have diarrhea We have trouble with the skin and I cannot understand, myself, why a machine that will produce the estimated depth dose of a machine at 800,000 on a patient 21 centimeters thick, does not produce complicating effects on the opposite skin portal

DR ROBERT R NEWELL (San Fran-

cisco) In the first place, Dr Leucutia has been looking into the future and talking about machinery for doing neutron production and nuclear reactions and artificial radio-activity and I am very fortunate in living just across San Francisco Bay from the first of the cyclotrons I went over and borrowed from Professor Ernest Lawrence a couple of Wilson cloud chamber pictures These are the original films he took with his Wilson chamber and he



let me have them to show you some of these reactions

This first one is the result from radioactive sodium produced by bombarding common salt with high speed deuterons from his cyclotron This breaks down into sodium again with the release of a high speed beta particle swifter than those from radium and a very hard gamma ray, harder than any from radium or thorium

These gamma rays came in here [pointing] and released some secondary beta rays The curvature in the strong magnetic field through the Wilson chamber indicates its energy, which is seen to be extremely high because it is not very much curved In the other film, we have some deuterons allowed to bombard beryllium,

26, 331-334) This was done at his request ]

DR WILLIAM E COSTOLOW (Los Angeles, Calif) The problem of determining the clinical value of supervoltage irradiation presents many difficulties, as does the determination of the value of the biologic and physical measurements which we heard about this morning

Erythemas have been mentioned I will briefly state our experience It was brought out this morning that in the production of an erythema by a single dose, a larger dose was necessary, and that the erythema came on at a later date when the supervoltage was used than when 200 kv was used This is perfectly true, but by fractionating the dosage over a period of five to six weeks, this difference is very difficult to detect For instance, in treating the pelvic conditions with supervoltage in cases in which we use as many as six portals, giving a total of from ten to twelve thousand r units over a period of five to six weeks, as compared with the same sort of cycle with 200 kv, applying the same total dosage in r (measured in air) over the same period of time, the erythema is very similar in its appearance and disappearance, and the condition of the skin several months later seems practically the same

We have had the opportunity of observing the use of 500 kv with 0.6 mm of lead filtration at our own office, and also the use of the 900 kv with 1 mm lead filtration, at California Institute of Technology We use the same r intensity per minute, and if we use the same size fields, daily dosages, and total days of treatment, the skin reactions produced by the two machines are apparently quite similar

Definite proof of the superiority of supervoltage, if any, will come only after five years, or longer periods of observations The only factor we can use now for basing any sort of comparison on, is, as Dr Schmitz has mentioned, the matter of the primary regression of the tumor This is quite difficult to determine clinically It

is quite inconclusive to compare the results in groups of cases treated in the past, in which the total dosage and time of treatment were less, with the results of the larger fractionated dosages now given

We must not forget the work that Dr Coutard and his associates have done in the pelvis with 200 kv, using large, prolonged, fractional dosages over multiple portals and obtaining disappearance of pelvic gland metastasis, which simulates any primary regression so far obtained with the supervoltage

In our pelvic cases we are getting better primary regression since using the supervoltage This may be because we are using larger dosages than formerly It is pretty difficult to compare the supervoltage results with work done previously with 200 kv, so the apparent improvement may be more a matter of total dosage than we think However, the question was brought up a minute ago as to whether we had treated any cases with supervoltages which had previously been treated with 200 kv We have Some of our old cases came back with recurrences after having had what we considered, at that time, adequate radium and x-ray dosages We have had complete regression in some of these cases after thorough supervoltage treatment These results are, of course, encouraging, but the cases are few, and, in the past, striking primary results were at times noted, following other forms of irradiation, although apparently not so frequently as at the present time One thing we may say that the supervoltage offers a method by which we can give the patient a very thorough course of irradiation While it appears that we are getting better primary regression, I feel that we had better do as the physicists and biologists all did this morning—beg off from making any definite statements until more time has elapsed to permit further observations

DR L S TAYLOR (Washington, D C) I would like to ask Dr Costolow what his alibi is when it comes to measuring these irradiations in roentgens

not mean, of course, that he feels the clinical results from treating pelvic tumors are the same with both types of radiation. I do not think he has yet made up his mind on this aspect of the problem.

Dr Taylor mentions that, with 200 kv radiation, physical measurements suggest that the correct focal skin distance should be approximately ten times that of the tumor depth. In view of this suggestion and in view of the fact that supervoltage is beyond the reach of many of us clinicians at the present time, I would like to ask Dr Failla if he thinks super-milliamperage would be a more economical and simpler answer to some of the problems involved.

Personally, I have operated an ordinary water-cooled 30 milliamperage tube at 40 milliamperes for several hours, without apparent damage—using 200 kilovolts. Now if one could secure 50 or 60 milliamperage tubes one could easily treat deep-seated lesions at target-skin distances of 100 centimeters as a routine measure. With such milliamperage the output with either 0.5 or 1.0 millimeter of copper filter would still be ample.

FRANK M. EXNER, M.A. (New York)  
May I ask how the measurements in roentgens at 900 kilovolts are made at San Francisco?

DR GARLAND: Well, Dr Stone has his machine calibrated by the physicists from the University of California and they think they are measuring similar roentgens.

Of course, like everybody else, they do not know, but they think they are measuring roentgens in air with 900 kilovolts.

LAURISTON S. TAYLOR (Washington, D.C.) Rather than present a discussion, I wish to make a short plea. We have listened all day until our heads ache about the difficulties in the measurement of supervoltage radiations. It is very unfortunate that so many of these installations, as they are put in, have to be installed in existing buildings and consequently have been

cramped as to space and lay-out of auxiliary apparatus.

I think it is highly necessary that those doctors who are considering new installations for voltages above 500 kilovolts ought to be a little public-spirited at the same time and make provision for some auxiliary space near their tube where adequate physical measurements can be carried out.

That means perhaps a little room off to one side—not so small, but a room where you can avoid scattering—where you can set up standard ionization chambers and make measurements under conditions wherein the scattered radiation can be controlled.

When a supervoltage x-ray installation is being built new, it is a simple matter comparatively to make such provision. After the installation is completed, it is a very difficult matter to make such provision.

I feel that questions of the type that have been raised all day will soon disappear if we can just have facilities available around the country for setting up apparatus and making unambiguous measurements.

Unfortunately, at the present time our laboratory, which is somewhat looked to for information of this sort, has no facilities whatever for carrying out such measurements. We have to go to outside laboratories, choosing here and there those particular ones which are suited to our purpose.

If, however, the next half-dozen installations which are built have provision made in their installation for some reliable physical measurements, and better still, if a physicist is attached to their staff to make these measurements, I feel the questions that are worrying us so much to-day will be more speedily rectified and answered.

GIOACCHINO FAILLA, D.Sc. (New York)  
The question of depth dose has been raised several times to-day, or at any rate it has been implied that with these very high voltage x-rays the depth dose must be very high.

As a matter of actual measurement, the

and the nuclear reaction has resulted in ejection of neutrons

Neutrons and  $\beta$  rays are not absorbed by the same mechanism. A neutron is without charge and runs through matter without being deflected or jostling the electrons at all, when it runs head-on into a nucleus of an atom, then it gives a transformation and you get a recoil ion, and these latter produce very intense ionization tracks, as shown in this Wilson cloud chamber photograph

Now I am very much interested in the minute mechanism of absorption of radiation within the human body, and when we compare the way a high speed electron is absorbed and the way a neutron is absorbed, we see that this [pointing to the track of the electron] is more or less like running a man through with a rapier. You can stick a man through the lung with a rapier and he may recover. But if you stab him with a flagpole [pointing to the recoil ion from the neutron absorption], I don't think he is going to recover at all.

So that I see some chance for selective action, some cells succumbing and some cells recovering (cancer being killed and normal cells recovering) when you use the secondary high speed electrons from photons (gamma rays or x-rays). But I do not see the medical use of neutrons when their ionization tracks are going to be so intense that you cannot imagine such a track going through a cell without killing the cell utterly, whether it is a cancer cell or a normal cell.<sup>2</sup>

GIOACCHINO FAILLA, D Sc (New York)  
I should like to bring out a point in Dr Holthusen's paper which perhaps might be misunderstood. Dr Holthusen did not present the erythema dose curve to show that there is no difference between x-rays and gamma rays, or, in other words, to show that there is no wave length effect,

because his curve was not determined with the same quality of radiation.

In order to eliminate the wave length effect from the curve, it would have been necessary to carry out all the experiments with the same quality of radiation, whereas that was not the case, since some of the treatments were given with 500 roentgens per minute and some with one roentgen per minute, and it is difficult to see how one can get such a variation in intensity, without changing the quality of radiation, and perhaps some other factors.

Therefore, the curve really shows the combined effect of prolonging the time and decreasing the wave length of radiation, in view of the fact that the short exposures were given with long wave length radiation, and the long exposures with short wave length radiation—possibly gamma rays.

In order to evaluate what part of the change is due to either factor individually, other experiments must be performed in which one or the other of the two variables is kept constant.

I think that this is in accord with Dr Holthusen's ideas, but I wanted to bring it out definitely so that there would not be any misunderstanding.

DR L HENRY GARLAND (San Francisco) As one interested in the clinical aspects of radiation therapy it has been a pleasure to listen to some of the papers read this afternoon, especially that read by Dr Emery (and also Dr Costolow's discussion thereof). It seems to be generally agreed that we are not yet in a position to decide the relative merits of high voltage (200 kv) and supervoltage (900 kv) radiation. From observations on some of the patients treated with the 900 kv apparatus at the University of California Hospital it is my impression that Dr Costolow's conservatism is more than justified. Dr. Stone unfortunately could not come to this meeting but he seems to have the impression that there is little clinical difference in either the amount of erythema or the type of reaction produced with these two very different voltages. This does

<sup>2</sup> Note added in proof. Considering Zirkle's figures on fern spores killed by x rays (*Am Jour Cancer*, March, 1935, 23, 558-567) I think I ought to have said merely that I think neutrons are not very promising for the treatment of cancer.

cause the intensity of ionization is very great. In these conditions the destruction of protoplasm is complete, and recovery impossible. Zirkle has observed the same phenomenon in fern spores. For equal amounts of ionization, he finds that the effect of alpha particles is greater than that of  $\lambda$ -rays.

CHAIRMAN FRANCIS CARTER WOOD, M D (New York). As a person interested in both the practical and theoretical sides, I hope that we will soon have some tests on patients actually using the Coutard method of the application of irradiation—irradiation given at from 3 to 4 r per minute over a long period. These radiations are all given rapidly, in ten- or fifteen-minute exposures.

It is very interesting to find out if, by doing what Dr. Coutard does—expanding that radiation over a couple of hours for each exposure—we would not get different results.

I have been interested in working the other way. I am treating a considerable number of patients with about 140 to 150 kv, with a half-millimeter of zinc, raising the skin-focus distance until the dose is something like 3 r per minute and then giving long exposures. There is not the slightest difficulty in giving 6,000 r on the skin of a patient in the course of a month

without getting a severe burn and very frequently with total disappearance of the metastatic carcinoma—for usually these are breast cases—from the surface of the chest and in that way I can guarantee no fibrosis of the lung is produced.

These big machines do produce fibrosis of the lung, as is well known. In some cases the fibrosis has been more serious than the primary disease from which the patient suffered, notably, cancer. It is like shooting at a *Drosophila* egg with a 13-inch Navy gun to use a very high voltage in treating superficial lesions!

Why do we have to use a ray which will penetrate the chest and ray people a block or two away when the dosage can be so adjusted that we can apply a sufficient dose to the two or three centimeters of thickness of tissue that we are treating, provided we alter the dose so that it conforms to the factors which Dr. Holthusen's charts show. The difference between the various doses of radiation affords a very valuable and useful check on our radiation therapy.

When you see that with 5 r per minute you can give a very much larger dose of radiation and that the danger of serious damage of the skin is considerably farther from the erythema dose than when the rate is 500 r per minute, we feel very safe in giving six and seven hundred r, if so desired, without producing serious damage.

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depth dose is not very different from that with 200 kv x-rays under the same conditions. So if the clinical results are better, the improvement cannot be attributed entirely to the increase in depth dose.

The foregoing statement, of course, is based on the present method of measuring depth doses, but I do not believe the present method is very good, and we shall have to wait until a better method is developed before we can say definitely what the depth dose is with the higher voltage x-rays and gamma rays. With the usual small chambers, having thick walls, there is surprisingly little difference in depth dose between 200 and 400 kv x-rays.

PAUL S. HENSHAW, PH.D. (New York)  
Dr. Packard in his main presentation has referred to the literature and pointed out that a large number of different wave lengths of x-rays have been used on a variety of different biological test objects and that practically no results were obtained which indicate a differential wave length effect. While this is true, it would probably be worth while to point out that the majority of these were carried out with x-rays produced at from 50 to 200 kilovolts. Surely it will be necessary to investigate the whole range of wave lengths of penetrating radiations, x-rays produced at from 50 to 1500 kv or more, before conclusions can be drawn.

For most of the investigations previously carried out, one ionization chamber was used to measure the radiation intensity and one test object was used to measure the biological effect. Recent results have shown that intensity measurements of different wave length radiations made with different kinds of ionization chambers may not agree. This tends to discredit statements about the wave length problem which are totally dependent upon ionization measurements. It seems to us that it would be more satisfactory to irradiate a variety of test objects with the different qualities of radiation and compare the relative effects produced in the different materials. This eliminates all ionization cham-

ber difficulties and compares tissue reactions directly, which really is the main point of interest in this work. It is to this kind of procedure that we attribute the fact that we have been able to observe differential wave length effects.

Packard has used one test object—*Drosophila* eggs—and ionization chambers and has found that the same relative effects are obtained in the eggs and for the ionization measurements for x-rays produced at from 12 to 550 kilovolts. We note, however, from his printed reports that certain corrections are necessary in case of the longer wave length (12 kv) radiations in order to make the results parallel. Among these is a correction of 6.7 per cent for differential absorption of the radiation at different levels in the *Drosophila* eggs, the greatest thickness of which is about 0.1 mm. While this correction is not large and would not change final conclusions to a great extent, I would like to know why Dr. Packard assumes that a correction must be made for the unequal distribution of radiation throughout the organisms. This question is raised because we have been able to produce killing in these organisms with alpha particles when it was known that the radiation did not pass to the center of the eggs.

CHARLES PACKARD, PH.D. (New York)  
Very soft radiations are so readily absorbed that their intensity is appreciably lowered after traversing even a fraction of a millimeter of tissue. Thus the nuclei on the under surface of the *Drosophila* egg receive less radiation than those on the upper surface. The average intensity was, therefore, calculated. The correction amounted to 6 per cent. If we had been wrong in our evaluation of the correction by even 20 per cent, that would have introduced an error of only one-fifth of 6 per cent, that is, about 1 per cent in the final result.

Dr. Henshaw has referred to his experiments with alpha rays which are wholly absorbed in the cells on the upper surface of the *Drosophila* egg. The egg is killed even though only a part of the cells composing it are injured. This is probably be-

ing of a vertical connective tissue fiber bundle. Sometimes a procession-like series of four or five such "travelling cells" could be followed away from the vertical bundle locus. At the end of five weeks most of the basal cells showed shrinkage of the nucleus and vacuolization of the cytosome. The contrast between these cells and those described as unaffected was very marked. The latter were now numerous and distributed along the whole length of the section although they were still more common near the vertical bundle terminations. At some points the epidermis was now only three cells thick. In the seven-week specimen there were at some places only two layers of epidermis but the basal layer was definitely on the way to recovery. The majority of the basal cells seemed normal and there was little vacuolization. The final sample, taken after ten weeks, showed three or four layers of cells with many of the normal type in the second and even the external layers.

The new cells which appeared at the site of the injury and formed part of the regenerating epidermis might be thought to be derived from mitotic divisions of the cells of the burned area or the zone just external to it which was included in the square of tissue examined. Counts of 10,000 cells for each specimen showed no significant difference between the number of mitoses in the irradiated and the control skin. These differences are shown in Table I.

TABLE I—NO MITOSES PER 1,000 CELLS

Weeks after 1 000 r	Control Skin	X rayed Skin
1	14	12
2	5	8
3	20	25
4	20	26
5	16	19
6	24	20
7	26	22
8	12	15
9	11	13
10	12	15
Totals	160	175

In cases in which an open wound is present, the epidermis of the frog is first completed through lateral migration of epidermal cells from the surrounding region (Arey). In the present series there was no open wound. Lateral migration is not indicated by the slides, and the time of appearance of new cells is not related to their distance from the edge of the injury. New cells are found near the center of the burn as soon as at its edge, and not only at the surface but beneath the injured cells. Appearing first at the loci of vertical connective tissue bundles, they are found in positions indicating that they have migrated along the bundles from the deeper layers and joined the dermis. In the normal dermis the vertical bundles bear similar cells, but in the x-rayed tissue there is an average increase in their number of 50 per cent for the ten-week period, with a high point of 100 per cent for the third week following irradiation. Table II gives the weekly counts of these cells.

TABLE II—"TRAVELLING CELLS" FOUND ON 25 VERTICAL CONNECTIVE TISSUE BUNDLES

Weeks after 1,000 r	Control Skin	X-rayed Skin	Percentage of Increase
1	198	266	35
2	190	278	45
3	188	400	113
4	260	350	45
5	185	263	40
6	145	250	83
7	155	375	77
8	218	278	26
9	186	224	20
10	178	201	18
Average	190	288	50

## SUMMARY

The epidermis, which was reduced by x-ray injury to two layers, was restored to four or five layers in thickness without significant increase in the mitotic divisions found and with no evidence of amitosis. Travelling cells of the dermis were much more numerous during the period of regeneration. These findings support the idea of replacement of epidermal by dermal cells.

# MITOSIS DURING THE HEALING OF X-RAY BURNS<sup>1</sup>

By JOHN A. CAMERON, M. A., Ph. D., *Columbia, Mo*

From the Department of Zoology, University of Missouri

CELLS lost by the epidermis after x-ray injury might conceivably be replaced through several processes. Mitosis of the remaining cells of the burned region is a method commonly described. Other possible means that have been described are amitosis (Kindred, 1927), lateral migration from nearby uninjured skin (Arey, 1932), modified mitosis (Stough, 1931), and migration and differentiation of cells of the dermis or of deeper layers of the body (Papanicolaou, 1933, and Cameron, 1936).

In the present series of experiments square burns  $6 \times 6$  mm were made on the backs of frogs by the application of 1,000 r. X-ray exposures were made in the laboratory of Professor L. J. Stadler, of the University of Missouri, with a Victor machine (Snook model), having mechanical cross-arm rectifier and universal type Coolidge tube operated at 140 kv. Tube current was 4 ma., target distance, 11 inches, time, 7 minutes, 24 seconds. No screen or filter was employed. Each frog was chlorotized during exposure, and the size and location of the injury were regulated by the size and position of a square hole in the lead plate that shielded its body. The output of 136.5 r per minute was measured with a Victoreen dosimeter. Each week for 10 weeks following irradiation a frog was killed and a square of skin  $18 \times 18$  mm which had the burned square as its center was fixed in Bouin's fluid. A control square was taken from each frog. Each piece of tissue was cut into serial sections 6 m $\mu$  thick and stained with Mayer's hæmalum and orange G.

<sup>1</sup> This study was aided by a grant from the Committee on Radiation of the National Research Council to W. C. Curtis.

In the distribution of mitotic figures and "travelling cells," no differences were found between specimens cut along the longitudinal and those cut along the transverse axes of the animals. A certain amount of shrinkage in the burned area resulted in some distortion of the cells around the periphery of the burn and in the drawing of neighboring cells out of the perpendicular in the direction of the center of the burn, but no evidence of lateral migration was found. The very low percentage of cells in mitosis detected in rapidly growing tadpoles made the modified mitosis described by Stough a very attractive explanation of the source of the new cells. Nevertheless, nothing indicating modified mitosis was seen in the slides, only normal mitoses were found, which suggests that the cells in mitosis were not present in the epidermis at the time of exposure to x-rays but have subsequently arrived from the deeper layers of the body.

One week after exposure the skin was reduced from six to five layers of cells, the control had three layers in the basal region in which metabolism was active but the irradiate had only two such layers. Many of the nuclei were swollen as though by excess fluid. The external layer of flattened cells was only loosely attached in the irradiate. In some of the sections the desquamated sixth layer was represented by long streamers of burned cells which dangled from the free border of the epithelium. After three weeks there were only four layers and all except the basal one were obviously undergoing degenerative changes. Among the old cells were some large, turgid, chromatic ones which appeared unaffected by x-rays, these being chiefly at places just external to the end-

## CASE REPORTS AND NEW DEVICES

### ENLARGED PARIETAL FORAMINA

#### REPORT OF AN ADDITIONAL FAMILY SHOWING THIS ANOMALY

By REUBEN G ALLEY, M D *Pittsburgh Pa*

From the Diagnostic X-ray Department of the Western Pennsylvania Hospital

Probably every roentgenologist has a varying number of films that are filed in a special place, with at least a mental note to the effect that more information is desired regarding them. These may be waiting for biopsy or operation or may even be kept with the hope

of finding a similar case that may shed light upon an unusual condition. Such a case of ours was brought to mind by the article of Dr O H Perry Pepper and Dr Eugene P Pendergrass in the January "American Journal of Roentgenology and Radium Therapy."

In July, 1933, an eight-year-old colored boy was injured by an automobile and routine skull films were taken. These revealed large, symmetrical, rather oval defects located in the parietal bones, just to the right and left of the mid-line (Fig 1). There was a definite bony septum between them. No other cranial ab-

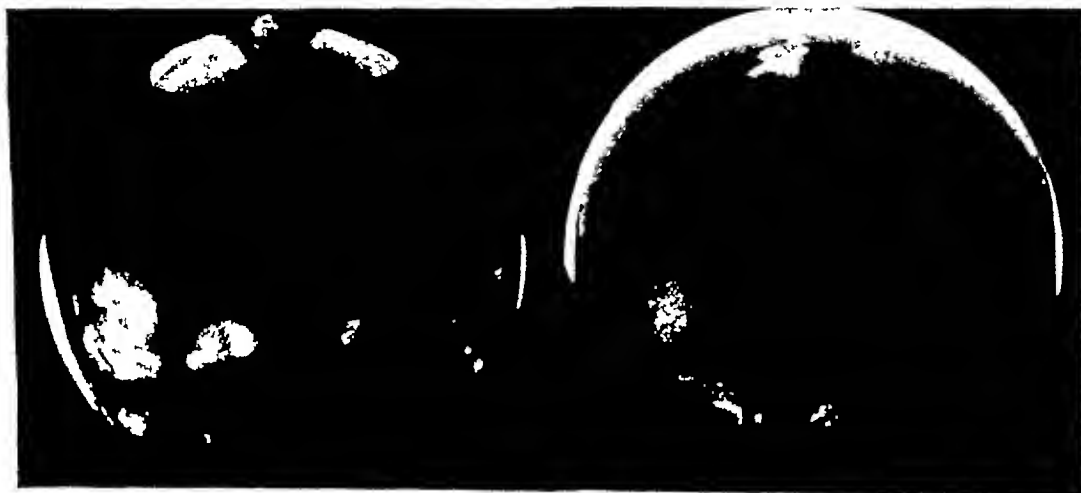


Fig 1

Fig 1 Robert aged 11 years was the first patient showing enlarged parietal foramina

Fig 2

Fig 2 Mrs B mother of all the children whose films are shown



Fig 3 Bessie aged 14 years

Fig 4 Lucky Jr aged 12 years

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(4) Palpable "soft spots" quite similar to the feel of a fontanelle,

(5) Their characteristic presence in other members of the family

After making the diagnosis, we wished to confirm the previous reports of hereditary transmission, so we located this family and were able to obtain x-ray examinations of the mother and six children. No other relatives live in this State, but the mother has promised to bring to us any members of her family who may come up from Texas.

Films of this colored family are here shown. The mother (Fig 2) has well outlined, enlarged foramina. They are less symmetrical and separated by a wider septum than noted on the first patient. The older girl (Fig 3) has these defects, but they are smaller than her mother's. This girl is fourteen years old and in her second year of high school. All of the children are alert and very interested in their self-styled "soft spots." In fact, the oldest boy (Fig 4) is very disappointed because he has none, and insisted that he have another x-ray examination to try to find that he was like his brothers and sisters. The twins (Figs 5 and 6) are a

very interesting study, and seem to prove that these enlarged foramina are no handicap to development. The girl has much wider defects, yet she is larger than the boy, appears older, though their mental development is approximately the same. The parietal foramen of the boy is indicated by an arrow on the film, for it is small enough to escape casual notice. The last film (Fig 7) is of the six-year-old boy. The bony defects are very noticeable when palpating his head, but strangely, the mother had never noticed them until these examinations were made. The thick, woolly hair possessed by each member of this family has probably been a great protection. These children complain of no headaches or undue pain in ordinary childhood injuries.

These additional cases are reported solely for their value in differential diagnosis. There is, at this writing, only one article on the subject in roentgen literature and these films will increase our available references and make interpretation of similar skulls an easier process than our efforts in 1933. Apparently they are of no clinical importance beyond elimination of a real pathologic lesion.

## OBSTRUCTION OF THE THIRD PORTION OF THE DUODENUM OF UNUSUAL ETIOLOGY

### REPORT OF A CASE<sup>1</sup>

By LESTER W. BAIRD, M.D., Fellow in Radiology, The Mayo Foundation and B. R. KIRKLIN, M.D., Section on Roentgenology, The Mayo Clinic, Rochester, Minnesota

Lesions producing obstruction of the third portion of the duodenum may be classified as intraluminal, mural, and extraduodenal. Obstruction may be produced by intraluminal lesions such as ingested foreign bodies and trichobezoars. Lesions of the mural type which may be responsible for obstruction include inflammatory lesions, benign and malignant tumors, and congenital stenosis. Since the third portion of the duodenum is retroperitoneal and crosses the vertebral column, it may be easily compressed by lesions in the surrounding tissues. Therefore, a large variety of extraduodenal lesions are comprised in this group, namely, congenital bands, particularly those extending between the transverse colon and jejunum, persistence of the anterior mesogastrium, adhesions to surrounding organs which are inflamed, such as the gall bladder,



Fig 1 Compression of the third portion of the duodenum and antral portion of the stomach by an extrinsic mass

<sup>1</sup> Submitted for publication May 12, 1936

normality was seen. When viewed in the stereoscope there was noted a gradual thinning of the parietal bone surrounding these defects, the skull was slightly large but showed no other

metry of the areas of decreased density, the smooth regular edges, and the lack of exophthalmos convinced us that Schuller-Christian's disease was not the causative factor



Fig 5 Paul aged 9 years a twin



Fig 6 Pauline aged 9 years twin sister of Paul (Fig 5)

type of pathology or anomaly. There was obviously no relation between these areas of decreased density and the injury. Lack of scars ruled out any previous operative work, though had only one such area been seen, history regarding an old trephine would have been investigated. Metastatic malignancy could be eliminated in diagnosis because of the child's excellent condition and the lack of any primary tumor. Also, there were no palpable tumors associated with the bone lesion. The sym-

Syphilis was considered but eliminated by serology. Finally, a diagnosis of congenital bony defects was agreed upon. We considered the appearance unusual because no similar skull defects were located in our available literature, and though the writer had viewed more than two thousand skulls in this department, no other such case had been seen. So these films were kept out of our regular file, waiting for more information to be obtained regarding them.

After reading the above mentioned article and also the references to "The Catlin Mark," by Dr. W. M. Goldsmith, in "The Journal of Heredity" for February, 1922, we were convinced that ours was a case of congenital enlargement of the parietal foramina.

On the posterior, superior aspect of the parietal bone, there is normally present a minute perforation that transmits a small vein to the superior sagittal sinus and at times a small branch of the occipital artery. Gray's Anatomy relates that this foramen may or may not be present and varies considerably in size, but even this did not prepare us to realize that the size could attain any such proportions as noted in our patient.

In brief, the points considered in diagnosing this case were as follows:

- (1) The relation of these defects to the parietal bone,
- (2) Their bilateral presence,
- (3) The lack of symptoms in the patient,



Fig 7 Floyd aged 6 years

## OSTEOCHONDRITIS DISSECANS OF THE CAPITELLUM OF THE HUMERUS

By LEO FREDERICK MILLER, M D, *Chicago*

From the service of Dr H B Thomas Orthopedic Department of the University of Illinois

Osteochondritis dissecans of the capitellum of the humerus is relatively rare, and only scattered reports are seen in the literature. This case is reported because it tends to further the explanation of the production of osteochondritis dissecans. Of those cases seen, the usual pathology of a dissecting fragment is already present and the diagnosis is quite obvious. It has been the writer's good fortune to observe this case over a period of months, with repeated roentgenograms taken at different intervals showing the development of the lesion.

The hypothesis as to the production of osteochondritis dissecans has been one of controversy since Monro advanced the theory of trauma as the basic cause for foreign bodies in joints. The literature can be divided into two groups as to the mode of production of the lesion—that in which trauma is the principal factor, and those factors other than trauma. It would be *apropos* at this time briefly to summarize the varied hypotheses.

*The Theory of Traumatic Origin*—This may be sub-divided into (a) subchondral fracture, (b) traumatic occlusion of the so-called end arteries of bone with the secondary involvement of the bone, (c) trauma resulting in inflammation of bone, or (d) superimposed injury on an already diseased bone.

*The Theory of Nontraumatic Origin*—This is (a) based on vascular involvement, (b) the result of inflammation, (c) heredity, or (d) chronic arthritis.

The study of the roentgenograms, or when the boy first appeared at the out-patient department, revealed a marked fragmentation of the capitellum of the humerus, and a definite zone of demarcation was present. The articulating surface was irregular and broken. After immobilization in a posterior molded cast, another film was taken one month later. The articulating surface had become more regular, and the fragments—which were three in the first film—now appeared as one. There was also a definite zone of absorption surrounding the fragment. The third roentgenogram, taken about one and a half months later, showed the presence of a cyst like area with no fragmentation visible. Crossing this area of rarefaction were bone trabeculae of a much coarser density. This rarefaction, however, was not so marked as it had appeared in the first roentgenograms. The fourth x-ray film was taken approximately six months after the boy appeared at the out-patient department of the orthopedic clinic.



Fig 1 Showing the fragmentation of the capitellum, with the articulating surface irregular and broken and the presence of a zone of rarefaction. Film taken on June 20, 1935.

It is felt that the osteochondritis dissecans can be explained on the basis of the history of trauma, which was slight but repeated in character. This trauma was produced by the action of the head of the radius upon the capitellum of the humerus, with the result that the so-called end arteries were injured and a necrosis was produced. Axhausen says, in his description of the mode of production of osteochondritis, "As the result of impaction of opposing articular surfaces, the blood vessels to the part are damaged, either with or without partial fracture, according to the severity of the violence. This leads to necrosis of the area supplied by the damaged vessels. Instead of a creeping substitution of the necrotic



stomach, or colon, lesions of the pancreas, particularly inflammation, carcinoma, or cysts, enlarged mesenteric lymph nodes, and, rarely, compression by the superior mesenteric artery in persons of asthenic habitus. Cases have been reported in which an enlarged spleen or liver, movable kidney, or abdominal aneurysm produced obstruction.

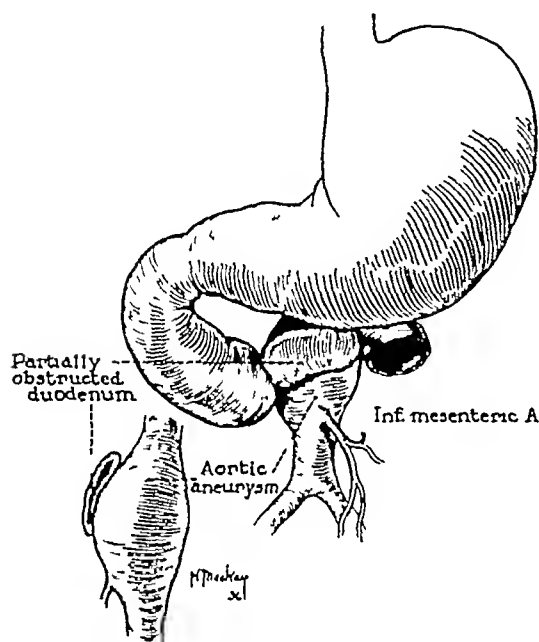


Fig 2 Illustrating the relation of the aneurysm to the duodenum as seen at operation

The symptoms caused by obstruction of the third portion of the duodenum resemble those of pyloric obstruction.

The case herein reported is one of obstruction of the third portion of the duodenum of extraduodenal nature, produced by pressure of an aneurysm of the abdominal aorta.

#### REPORT OF CASE

The patient, a white woman, aged 67 years, was admitted to the Clinic on Nov 6, 1935, complaining of nausea and vomiting of two months' duration and of loss of weight. Approximately three years previously she had first begun to have symptoms of indigestion which lasted about ten weeks. During this time she had vomited almost constantly, regardless of whether she ate or not. Once during an attack she had vomited blood. These

symptoms had then gradually disappeared without any particular treatment, and the patient regained her weight and strength. About two months before her admission, the previous symptoms recurred and then gradually progressed to the point where she could retain nothing on her stomach. A month later she noticed a mass in her abdomen which she thought had gradually increased in size.

On physical examination at the Clinic, the patient appeared to be well developed, but poorly nourished, weak, and obviously ill. The lungs were normal; the cardiac borders were within normal limits, and the heart beats were regular and clear. There was a palpable mass over which a faint bruit was audible, in the upper part of the abdomen, with visible, but not expansile, pulsation. The laboratory findings were as follows: urine, normal; hemoglobin, 15.9 gm per 100 c.c.; leukocytes, 8,900 per cubic millimeter; flocculation test, negative, and total gastric acids 32 and free hydrochloric acid 16 units (Topfer's method). One hour after an Ewald test meal, 150 c.c. of gastric content was aspirated; this did not contain remnants of food but did contain a slight trace of blood. Occult blood was present in the stools.

On Nov 15, 1935, roentgenoscopic examination of the stomach disclosed rather marked dilatation of the second portion of the duodenum and some stasis. There was a defect in the third portion of the duodenum indicative of an extrinsic lesion causing obstruction by pressure. As a pulsating abdominal mass was present in this region, it was surmised that the obstruction was caused by an aneurysm of the abdominal aorta. The clinical diagnosis was obstruction of the third portion of the duodenum, either by a dilated, tortuous aorta, or by an abdominal aortic aneurysm of diffuse type (Fig 1).

On Nov 22, 1935, the patient was operated on to relieve the obstruction. The stomach and duodenum were carefully examined but no evidence of an inflammatory lesion was found. There was, however, hypertrophy and dilatation of the duodenal wall, the result of an obstruction by an aneurysm of the abdominal aorta which measured approximately seven and one-half inches (19 cm) in diameter (Fig 2), for relief of which a posterior gastro-enterostomy was performed.

Obstruction of the third portion of the duodenum alone is a rather uncommon finding, and aneurysms of the abdominal aorta are likewise rare, particularly in that portion where the duodenum crosses the aorta. Rarer still, therefore, is obstruction of the third portion of the duodenum produced by an abdominal aneurysm.

marked in a combination of rotation and extension movement of the elbow joint. There was a loss of from 20 to 25 degrees of extension, and passive extension was not possible because of pain. The range of flexion and rotation was normal.

**Treatment**—This consisted of the application of a posterior molded cast, and baking to the right elbow joint. The boy was kept under observation, and, at present, he has a loss of only five degrees of the carrying angle of the right elbow joint and is free of pain.

## RADIOGRAPHIC TECHNIC FOR ACROMIOCLAVICULAR DISLOCATION<sup>1</sup>

By GERTRUDE R. PEARSON, R.T. Greeley  
Hospital Greeley, Colorado

A review of the available literature does not teach us a method of roentgen examination which consistently shows acromioclavicular dislocation. The purpose of this paper is to pass on to others a radiographic method which, we have learned, reveals this injury in most cases. Routine shoulder radiography does not exclude acromioclavicular dislocation, even when the findings are apparently those of a normal shoulder.

Physicians tell us that acromioclavicular separation is ordinarily the result of direct force. When diagnosis and specific treatment are not accomplished early the patient is usually subject to "drop shoulder," which may hinder his daily activities.

If the superior and inferior acromioclavicular ligaments are injured, they go on to say, the major attachments of the acromion process and clavicle are severed. When the patient with an acromioclavicular dislocation is standing, the scapula sags slightly, separating the distal end of the clavicle from the acromion. If the patient is supine, the scapula is pushed upward so that, usually, the parts assume their normal relationship.

As an x-ray technician, I have x-rayed several cases which, the radiologist stated, showed separation plainly in the radiograph made when the patient was in the erect posture, but which presented normal acromioclavicular relationship in those plates made in the usual recumbent posture.

Figures 1 and 2 are reproductions of one of the cases. Note that the joint relations appear normal in the routine plates and severe acromioclavicular dislocation is recorded in those made on the same patient in the erect posture.

<sup>1</sup> Submitted through the advice of K. D. A. Allen, M.D.

## SUMMARY

A case of osteochondritis dissecans of the capitulum of the humerus is reported. The theory of the mode of production is based on the hypothesis of Axhausen.

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- (2) AXHAUSEN. *Die Entstehung der freien Gelenkkörper und ihre Beziehungen zur Arthritis deformans*. Arch. f. klin. Chir. 1914, 104, 581.



Fig 1 Radiograph of a shoulder made in the routine supine position showing normal appearance of acromioclavicular joint



Fig 2 Radiograph of the same patient as illustrated in Figure 1 made in the erect posture showing acromioclavicular dislocation

## SUMMARY

1. Acromioclavicular dislocation is often overlooked clinically and is usually not shown on the routine anteroposterior films.

2. A series of cases reveals to the radiologist that acromioclavicular dislocation is demonstrated on films made in the erect posture.

Child Research Council,  
4200 East Ninth Ave.,  
Denver, Colorado

and overlying cartilage as would result in a case of aseptic necrosis in other regions, there

forms a zone of absorption resulting in a gradual separation and eventually an extrusion



Fig 2

Fig 2 The fragmentation disappearing and a very definite zone of demarcation Film taken on August 27, 1935



Fig 3

Fig 3 Showing the presence of a cyst like area Film taken on Oct 4 1935



Fig 4 Showing the typical picture of osteochondritis dissecans Film taken on Dec 6 1935

of the dead portion of bone into the joint " Axhausen's theory can readily be applied in this case, as seen in the serial roentgenograms

#### REPORT OF CASE

*History*—H L, a white boy, 15 years of age, entered the orthopedic dispensary of the University of Illinois on June 14, 1935. The patient complained of a limitation of movement of the right elbow joint which, when in motion, was painful. There was a slight swelling as compared to the left joint. These symptoms had been present for the past month. He stated that he had never been troubled with the joint before the onset of pain. The patient attributed the onset to throwing newspapers daily while working on his newspaper route. The pain and limitation becoming gradually worse, the patient came to the clinic for treatment.

*Physical examination* revealed a tall boy, proportionally developed, with no evidence of endocrine disturbance. The essential findings were in the right elbow joint, where there was a localized puffiness just lateral to the olecranon process, with the skin of normal color. The lateral condyle was painful to slight pressure but no localized point of tenderness was present. Active motion revealed that the pain was most

ing the posture described above, the roentgenogram may be made with the subject in the supine position. The tube is obviously placed

on the side, and the suspected hip elevated to make up for the required  $10^\circ$  backward inclination.

# SOLITARY OSTEITIS FIBROSA CYSTICA, COMPLICATED BY PATHOLOGIC FRACTURE AND TREATED LOCALLY BY ROENTGEN RAYS

By E. A. POHLE, M.D. Ph.D. and L. W. PAUL, M.D. *Madison, Wisconsin*

From the Department of Radiology and Physical Therapy, University of Wisconsin Medical School

Osteitis fibrosa cystica in children is amenable to roentgen therapy, one must remember, however, that only moderate doses are indicated. If a pathologic fracture occurs

February, 1934, after having fallen several times, an x-ray examination was reported as showing "infected" bone and an old fracture in good position. Three days before admission to this hospital she fell again and injured the arm. The referring physician examined the arm with x-rays and found a pathologic fracture. The past medical history, other than that referable to the arm, was essentially negative.

Physical examination showed a child with normal development and nourishment for her age. The only pertinent findings were in the right arm. The right shoulder was depressed and the axillary fold was broadened anteriorly.

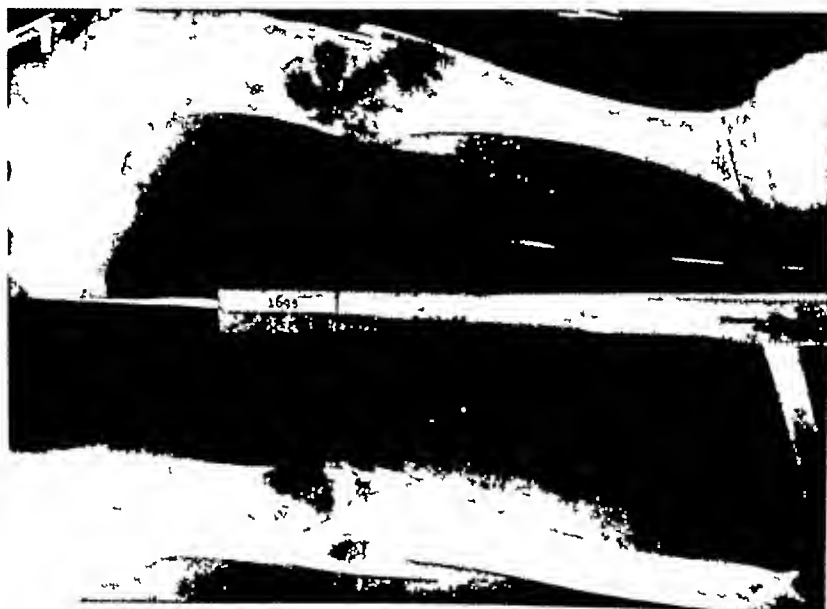


Fig. 1. Roentgenogram taken on April 1, 1935, shows a pathologic fracture of the right humerus near the middle. Multilocular cystic lesions involving the proximal half of the humerus may be seen. There were no changes in the epiphysis.

in such an affected bone, it may heal satisfactorily following simple fixation (Geschickter). However, irradiation may definitely improve the end result and hasten calcification of the cystic area. A case of this type will be reported below.

D. R., x-ray No. 4,683, white female, aged 6 years, was admitted to the orthopedic service of the State of Wisconsin General Hospital on March 28, 1935. At the age of two, she had injured her right arm by falling from a chair. The arm hung limp at the side for several days but she then regained normal use of it. In

The right arm measured seven and one-fourth inches in its greatest diameter as compared to six inches for the left. There was inability to abduct the shoulder or flex the forearm, and palpable crepitation and motion at the junction of the upper and middle thirds. A roentgenogram of the right humerus (Fig. 1) showed a pathologic fracture near the middle and osteitis cystica involving the proximal half of the humerus. No other bones were affected. Routine blood studies revealed a mild secondary anemia. The urine showed a trace of albumin on two occasions. The blood Wassermann was

# LATERAL ROENTGEN-RAY STUDY OF THE HIP JOINT<sup>1</sup>

By LEWIS J. FRIEDMAN, M.D., *New York City*

There have been many methods described during the past few years, each tending to simplify the lateral projection of the hip joint. The author wishes to present still another method which, in his experience, has proven to be simplicity itself.

There is no need for any unusual devices, since the standard Bucky table, cassette, and tube stand are employed. The position of the patient and the proper angulation of the roentgen-ray tube are the only requisites necessary for assuring proper technique.

Figure 1 depicts a pelvis and both femora placed almost laterally but with a 10° backward inclination of the normal side, the cone is inclined upward about 35°. In this position, the projected central rays are directed anteriorly to the normal femur and through the inferior surface of the femoral cervix under study.

The resulting radiograph (Fig. 3) reveals slight elongation of the femoral neck and exaggeration of the fracture which is actually

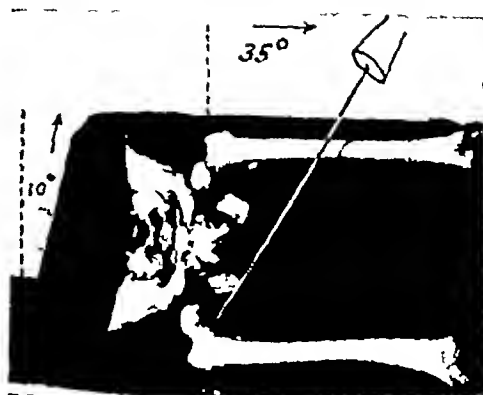


Fig. 1. The pelvis and both femora are placed almost laterally, but with a 10° backward inclination of the normal side, the cone is inclined upward about 35°.

present in this patient. In more extensive fractures, the position of the neck in relation to the trochanters may also be vividly seen. In the conventional study of the hip joint, one can occasionally notice only extremely vague evidences of fracture, as shown in Figure 2, a radiograph taken of the same patient as Figure 3.

Should the patient have difficulty in assum-



Fig. 2



Fig. 3

Fig. 2. Conventional study of the hip joint showing only extremely vague evidences of fracture.  
Fig. 3. When the patient is placed in the position suggested by the author, the resulting radiograph reveals slight elongation of the femoral neck and exaggeration of the fracture which is actually present.

<sup>1</sup> Accepted for publication Dec. 13, 1935.

ing the posture described above, the roentgenogram may be made with the subject in the supine position. The tube is obviously placed

on the side, and the suspected hip elevated to make up for the required 10° backward inclination.

# SOLITARY OSTEITIS FIBROSA CYSTICA, COMPLICATED BY PATHOLOGIC FRACTURE AND TREATED LOCALLY BY ROENTGEN RAYS

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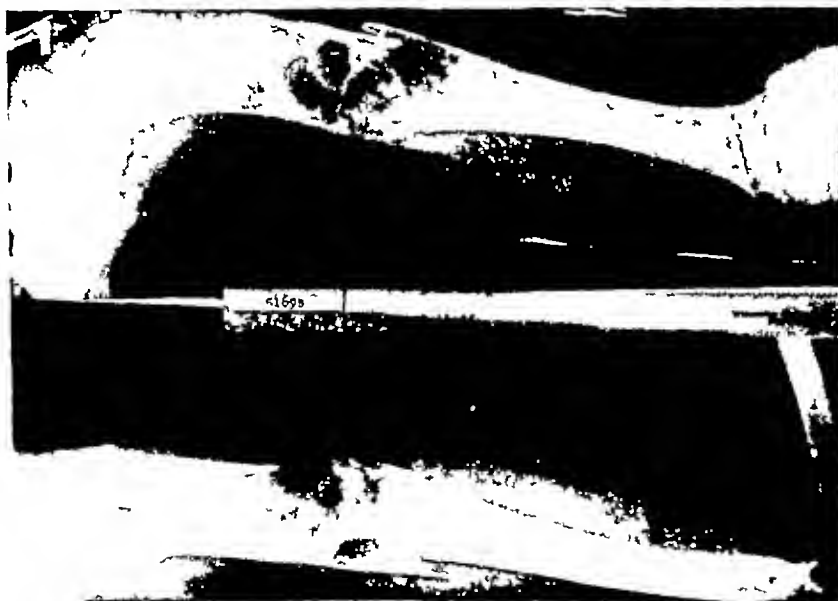


Fig. 1. Roentgenogram taken on April 1, 1935, shows a pathologic fracture of the right humerus near the middle. Multilocular cystic lesions involving the proximal half of the humerus may be seen. There were no changes in the epiphysis.

in such an affected bone, it may heal satisfactorily following simple fixation (Geschickter). However, irradiation may definitely improve the end result and hasten calcification of the cystic area. A case of this type will be reported below.

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negative On July 17, the blood calcium was 29, 1935, orthopedic treatment consisted of adhesive traction The fracture had healed 10.3 mg per 100 c.c., while the blood phosphorus was 4.4 mg (normal values 10-12 mg, and 4-5 mg, respectively) Until April



Fig 2 Roentgenogram taken on April 29 1935 after the removal of traction and before the starting of x ray therapy There is union of the fracture with callus formation, expansion of the shaft persists

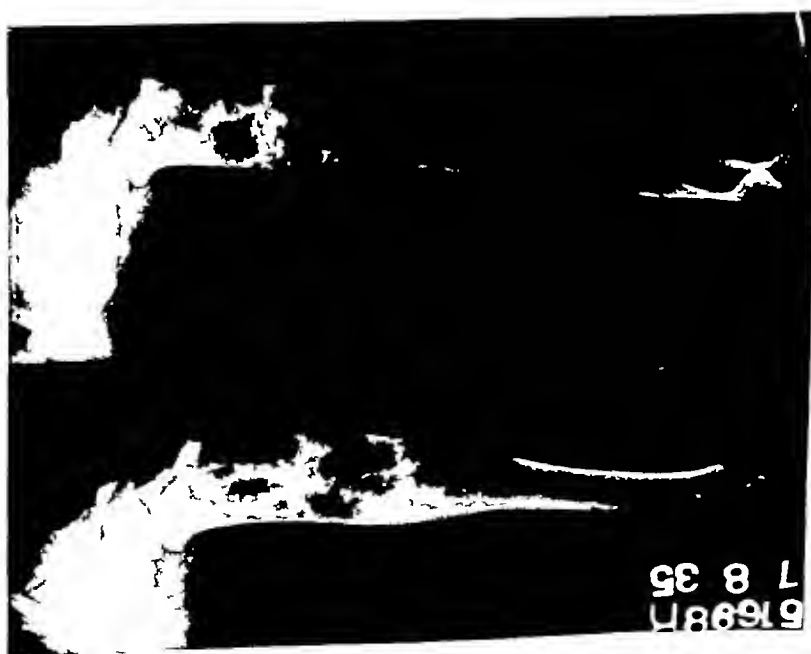


Fig 3 Roentgenogram taken on July 8 1935 shows the fracture healed in good position There is a beginning recalcification of the cysts

(Fig 2) and the patient was referred to us for irradiation of the cystic lesions



Fig 4 Roentgenogram taken on Feb 3 1936, shows further calcification of the upper humerus with reduction in diameter of the involved bone

A total of three series of treatments directed to the anterior aspect of the upper right humerus was given in May, July, and October, 1935. Each series consisted of three sittings on alternating days, the dose amounted to 150 r (in air), half value layer in copper = 0.8 mm. Recalcification was noted in July (Fig 3), and a more recent examination on Feb 3, 1936, showed further calcification and reduction of the diameter of the involved bone (Fig 4).

The question arises, of course, whether or not the healing fracture alone with its accompanying shift of calcium would have brought about this end-result. We feel, however, that x-ray therapy was of definite benefit particularly because of the continued calcium deposit after the fracture itself had healed (compare Figs 3 and 4). The decrease in the size of the cysts was most marked during the period from July, 1935, i.e., two and one-half months after healing of the fracture (Figs 2, 3, and 4) to the date of the last examination. The probability of a spontaneous healing cannot be ruled out entirely.



## WHITHER RADIOLOGY?

Two radiologists, one a veteran and the other of the younger generation, delivered presidential addresses last week—Dr L A Rowden, of Leeds, from the chair of the British Institute of Radiology, and Dr C G Teall, of Birmingham, from that of the Section of Radiology of the Royal Society of Medicine. Dr Rowden's address was an interesting excursion into the past. Just as there is a generation growing up to whom the war is only a tale told them by their fathers, so there are radiologists who have had no experience of inadequate apparatus or makeshift provisions, although the history of x-rays is comprehended within less than forty years. Dr Rowden described the old tubes, coils, and mercury breaks, also the early measures for protection, which were not so inefficient as some people think. Dr Teall, on the other hand, looked forward, counting himself fortunate to belong to a generation of radiologists who had known nothing but good apparatus of increasing facility. There was, however, one bogey about apparatus he wanted to lay. It was often asserted that with the advent of the push-button type of equipment almost everyone would be able to produce satisfactory radiographs. Unless the radiologist had the necessary knowledge of anatomy his beautiful picture might be quite useless, and the idea should be discouraged that radiographic technic was now quite easy. Dr Teall went on to point out that with each fresh advance radiology was becoming more highly specialized. Two classes of radiologists were being developed: one the skilled consultant, the other the general practitioner of radiology. Advance would largely be made by the men who had taken a special interest in one branch of their work. On the other hand, while radiology became every year more specialized and difficult, comparatively cheap apparatus was also available. In the large towns a good radiological service in which the best type of apparatus was employed was

usually provided, but the position was different in out-of-the-way districts, and this simpler apparatus enabled the country practitioner to make use of x-rays in his practice. The right policy was not to try to stop the use of such apparatus, but to ensure that practitioners who employed it were instructed in its legitimate application and limitations. If only medical students were given an adequate knowledge of radiology in their curriculum, any danger from the more general employment of small apparatus would not be apprehended. Practitioners varied very much in the use that they made of the x-ray method. Some resorted to it infrequently, and their patients suffered in consequence; others relied too much upon it, and again their patients suffered. Dr Teall desired to see the medical profession more radiologically minded, in the true sense of the word. The hospitals were now equipped with departments capable of all types of x-ray work, and the cost of such departments, both capital and maintenance, was very high. At the same time, many hospitals were adding private beds, and to the patients in such beds the facilities of these well-equipped departments would be available. The private radiologist could not compete with the service thus provided, and the radiologist, like the physician and surgeon, would do more and more of his work in institutions.

In conclusion, Dr Teall referred to the Cambridge diploma in radiology. This and other diplomas since inaugurated had become not only recognized but regarded as an essential qualification for anyone who proposed to take up radiology. He wished it could be made one of the requirements for obtaining the diploma that candidates should have held at least one medical or surgical resident appointment. Many radiologists now took the view that a higher qualification still was necessary if the standard of radiology was to be maintained at a sufficiently high level to keep pace with developments in therapeutics and in diagnostic work. It might then be possible

<sup>1</sup> Reprinted by permission from *British Med Jour* Oct 26 1935

to develop a college of radiology in which all the developments of radiological work would be fostered and co-ordinated. He believed that must be the ultimate goal.

NOTE BY THE EDITOR OF "RADIOLOGY"

Such a College of Radiology as Dr. Teall has envisaged has been established in North America, and now has an honorable record of several years' achievement and a membership composed of the most outstanding radiologists in the country.

## COMMUNICATION

### THE INDIANA ROENTGEN SOCIETY

The ninth annual meeting of the Indiana Roentgen Society was held in Indianapolis on June 7, this year. Dr. John D. Camp, of Rochester, Minn., addressed the society. His subject was "X-ray Findings in Spinal Cord Tumors."

The following officers were elected for the coming year: *President*, E. M. Van Buskirk, M.D., of Fort Wayne; *President-elect*, James N. Collins, M.D., of Indianapolis; *Vice-president*, H. H. Inlow, M.D., of Shelbyville; *Secretary-Treasurer*, Clifford C. Taylor, M.D., of Indianapolis.

## ANNOUNCEMENTS

### AMERICAN RADIUM SOCIETY

The next meeting of the American Radium Society will be held in Atlantic City, the Monday and Tuesday during the meeting of the American Medical Association, in the Spring of 1937.

The officers are:

*President*, Zoe Allison Johnston, M.D., Pittsburgh

*President elect*, Edward H. Skinner, M.D., Kansas City

*First Vice-President*, Charles L. Martin, M.D., Dallas, Texas

*Second Vice-president*, O. N. Meland, M.D., Los Angeles, Calif.

*Treasurer*, Lawrence Pomeroy, M.D., Cleveland, Ohio

*Secretary*, William P. Healy, M.D., New York City

## BIOLOGICAL PHOTOGRAPHIC ASSOCIATION

The Biological Photographic Association extends a cordial invitation to all photographers and scientists interested, to visit its Sixth Annual Convention in Boston, Sept. 24-26, at the Hotel Lenox. Among others, the following papers will be presented:

Ultra-slow Mercuric "Spark" Motion Picture Apparatus, Dr. E. H. Edgerton, Massachusetts Institute of Technology

Print Quality, Ralph P. Creer, Veterans Administration, Hines, Ill.

Infra-red Photography, Leo C. Massopust, Research Laboratory, School of Medicine, Marquette University, Milwaukee, Wis.

A paper on Optics (title to be announced), Professor A. C. Hardy, Massachusetts Institute of Technology

Ortho-stereoscopic Photography, Mr. Henry F. Kurtz, Scientific Bureau, Bausch & Lomb Optical Company

Motion Pictures as an Aid in Teaching Entomology, Dr. C. T. Brues, Department of Biology, Harvard University, Cambridge, Mass.

Experimental Motion Pictures of the Larynx, Leonard Juhn, Mayo Clinic, Rochester, Minn.

The exhibition will consist of photographs from all over the country and the most modern equipment and supplies.

The Association publishes a quarterly journal. It circulates its print exhibition as a travelling salon. It has a series of instructive illustrated loan albums for the use of its members.

Active membership is open to those whose duties include biological photography. Any one who is interested in such photography may become an associate member. The annual dues including journal subscription, are \$3.00.

Address the Secretary, Miss Anne Shiras, Magee Hospital, University of Pittsburgh, Pittsburgh, Pa.

Many members of the Radiological Society of North America will be interested in the activities of this Association because of a common interest in many phases of scientific photography.

## NOTICE OF CORRECTION

In the paper by W. S. Middleton, O. O. Meyer, and E. A. Pohle entitled "The In-

fluence of Roentgen Therapy upon the Basal Metabolism in Leukemia," which appeared in the May issue, 1936, 26, 586-594. Charts I and II should be reversed. The legends are correct as appearing in the paper. The authors overlooked the matter in their proof.

## BOOK REVIEW

"MEDICAL PAPERS," dedicated to Henry Asbury Christian from his present and past associates and house officers of the Peter Bent Brigham Hospital, Boston, Massachusetts, in honor of his sixtieth birthday. Edited by ROBERT T. MONROE, M.D., Peter Bent Brigham Hospital. A volume of 1000 pages. Published by William Wood & Company (Waverly Press, Inc., Baltimore, Maryland, 1936). Price, \$10.00.

This book in honor of Dr. Christian's sixtieth birthday contains over one hundred medical articles, each written expressly for the volume by Dr. Christian's present and past associates and house officers at the Peter Bent Brigham Hospital. The list of contributors contains the names of a remarkable number of men who are prominent to day in American medicine, and serves to emphasize the great and widespread influence that Christian has had on medical thought in this country.

The subjects presented vary widely. Case reports, of which there are several, show the results of Christian's influence in the meticulous care with which the cases have been studied and the observations set down. The subject matter of the book is, in general, excellent. Aside from a few papers of a general nature, there are papers on circulatory disorders, renal diseases and diuretics, diseases of metabolism and the ductless glands, pulmonary diseases, diseases of the blood and liver, studies of the function of the intestines, studies of several infectious and parasitic diseases, and a group of miscellaneous papers. An excellent sketch of Christian's scientific life is given. The book is closed with a register of former and present members of the Peter Bent Brigham Hospital medical staff.

The volume presents an excellent cross section of present-day medicine, and contains more authoritative and valuable information. It is to be regretted that there is no index. As a tribute to Dr. Christian, the book serves its purpose fittingly and admirably. It will, of course, be of particular value to the many distinguished members of the staff, both past and present, of the Peter Bent Brigham Hospital and to the hosts of friends and students of Dr. Christian.

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J E HABBE M D of Milwaukee Wisconsin	W A SODEMAN, M D, of New Orleans
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H A JARRE M D, of Detroit, Michigan	

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## ABSCESS, PULMONARY

Serial Bronchography in the Diagnosis of Suppurative Pulmonary Processes Pedro L Fariñas Am Jour Roentgenol and Rad Ther November 1935 34, 579-591

For two years the writer has been studying cases of pulmonary abscess in various stages of development by the use of serial roentgenograms made under roentgenoscopic control after the injection of lipiodol through a catheter previously introduced through the nasal fossa and larynx into the main stem bronchus on the side of disease

In the very earliest stages of development of an acute abscess there are no characteristic abnormalities of the bronchogram for in this stage the bronchial walls have not suffered the effects of the inflammatory process long enough to lose their elasticity and dilate. The iodized oil will not penetrate the alveoli which are filled with purulent exudate hence the bronchographic appearance is that of a tree without leaves. Somewhat later even after the formation of the cavity has progressed farther it may be so full of secretion and the bronchial communication so inadequate that the oil will still fail to penetrate except where there is communication with the large bronchus, in which case the cavity proper may be demonstrated in the roentgenogram. Later, after the pneumonic process has resolved, the alveolar dispersion of the oil can be noted and the appearance of the bronchial tree is that of a tree with its leaves. At times, after the cavity has been draining for a while there may be a cylindrical or ampullar dilatation of the bronchus draining the cavity while the rest of the bronchial tree remains normal. There is another type of case especially in post operative abscess, in which there may be very early manifestations of cylindrical dilatation of the affected bronchi. In these cases the oil may not penetrate beyond the dilated medium size bronchi and in this event the appearance is that of a dead tree. Sometimes when a bronchopneumonic process becomes suppurative the oil filling will demonstrate numerous small abscesses separate one from another.

In the chronic cavity formation there is usually ample bronchial communication and the filling of the cavity proper is readily accomplished. Very commonly even when the draining bronchus presents a relatively normal appearance, the bronchi toward the base of the lung on the same side will show cylindrical and sacciform dilatation. These changes in the basal bronchi are believed to be due to the constant tendency toward drainage of purulent bronchial secretion into this part of the tree.

Sometimes the differentiation between bronchiectatic abscess and abscessed bronchiectasis may be difficult, in the former condition there is apt to be a larger central cavity, with smaller sacciform cavities around it while in the latter condition of abscessed bronchiectasis all of the cavities are of about the same size.

In ulcerating bronchial carcinoma a filling of the cavity with oil may occur but one will not find sacciform dilatations of the bronchi about this area.

In ulcerating lobar carcinoma, the cavity generally does not fill and the whole bronchial tree at this level is displaced by the tumor

J E HABBE, M D

## ANIMAL EXPERIMENTATION

Production of Sarcoma by Colloidal Thorium Dioxide in the White Rat. G Roussy Ch Oberling and M Guerin Strahlentherapie, 1936, 56, 160

When studying the effect of colloidal thorium dioxide on transplanted tumors of the white rat the authors noted the appearance of a peritoneal sarcomatosis one year after thorotrast injections. This induced them to study the possibility of further producing sarcoma by injections of thorotrast. In rats, mice, and chickens it was possible to produce sarcomatous neoplasms which were eventually fatal to the carrier. A series of photomicrograms are appended showing the histologic structure of the tumors.

While there may be no danger of development of sarcoma in patients who receive thorotrast injections for diagnostic purposes, the authors feel that caution is indicated when using even slightly radio-active substances.

ERNST A POHLE M D, Ph D

Observations of Cell Changes during Roentgen Irradiation J Heeren Strahlentherapie, 1936, 55, 263

The author studied the effect of roentgen rays on frog muscles and on liver cells during irradiation. The technic is described in detail. The frog muscle contracts during irradiation. Whether or not a second exposure produces the same phenomenon depends on the condition of the muscle and also on the time interval between the two exposures. The magnitude of the dose has undoubtedly also some influence on the reaction. The metabolism of liver tissue is definitely decreased during irradiation provided that the cells are exposed in Ringer's solution. If serum is used, there is hardly any change in the metabolism to be detected. Further investigations regarding qualitative changes in the irradiated cells are promised.

ERNST A POHLE, M D, Ph D

Radiobiologic Studies on the Skin of the Himalaya Rabbit O Becker Strahlentherapie, 1936, 55, 316

The author compared the effect of Grenz rays (9 kv) and roentgen rays of moderate penetration (150 kv 3 mm Al). It appeared that neither erythema nor pigmentation constituted suitable reactions for such a study. However, the desquamation in the skin could be used. It occurred after 650 r of Grenz rays and 750 r of roentgen rays of the quality described above. There was no difference in the cumulation of the dose between Grenz rays and roentgen rays.

ERNST A POHLE M D, Ph D

X ray Diffraction Patterns from Reprecipitated Connective Tissue Ralph W G Wyckoff and Robert B Corey Proc Soc Exp Biol and Med, March, 1936 34, 285-287

A series of experiments was carried out to determine (a) whether reprecipitated tendon is really crystalline and (b) whether its x ray diffraction pattern is like that of the original tissue

Using acid solutions of tail tendon from adult rats x ray diffraction studies have been made Diffraction patterns were photographed and measured from (1) the original tail tendon after drying over  $P_2O_5$  (2) reprecipitated tissue dried under tension, (3) the extracted tendon dried under tension Results prove that reprecipitated tissue shows exactly the same x ray diffraction lines as the original tendon Such a reprecipitated tissue can differ only slightly if at all from the original either in chemical composition or in crystalline array Since such collagen solutions may be expected to contain substantially the same large molecules that have gone to make up the original connective tissue a study of such solutions can hardly fail to throw light upon the nature of these molecules

W A SODEMAN M D

The Behavior of Reticulocytes of the White Mouse Following Roentgen Irradiation H Langendorff Strahlentherapie, 1936, 55, 307

In this first paper the author studied the effect of a single dose of roentgen rays on the reticulocytes of the white mouse The animals were kept one week under the same conditions and then exposed to 180 kv, 3 mm Al for from one to 18 minutes corresponding to from 50 to 800 r The animals tolerated this dose fairly well except that two mice exposed to 800 r died The normal value for reticulocytes in the white mouse was determined in 118 animals it amounted to 89.6 o/o The count was taken daily following irradiation and the results were plotted The resulting curve corresponded to the erythema curve of the skin or to a mitosis curve determined following roentgen exposure If the animals were anesthetized the effect of irradiation was more pronounced Various narcotics showed however, a difference in this reaction No permanent injuries of the reticulocytes could be observed even though the dose used approached the lethal dose

ERNST A POHLE M D Ph D

## APPARATUS

Continuously Evacuated X-ray Tubes T E Allibone Proc Royal Soc. Med March, 1936 29, 439-448

Allibone reviews the development of the methods of evacuation of the x ray tube to the use of the vapor condensation pump C R Burch, of the Metropolitan-Vickers Electrical Company while studying the oil impregnation of a number of insulating materials under vacuum discovered that he could separate the light fractions of the oil from the heavy, thus collecting a fraction with very low vapor tension This oil could

be employed in a single stage metal condensation pump which once used mercury to produce pressures far below that of "x ray vacuum" without the necessity for a cooling reagent He could produce pressures as low as  $10^{-4}$  dynes/cm<sup>2</sup> at normal temperatures Burch also discovered a number of low vapor tension viscous fluids which can be used for sealing joints and the like

With the need for a refrigerant eliminated it was possible to construct an x ray tube of durability and with very low pressure by the use of continuous evacuation Experimental x ray tubes and rectifiers have been evacuated by these oil pumps and operated up to 350 kv A tube for medical deep x-ray therapy has been constructed which is efficient almost indestructible and shockproof This new tube can operate at any current up to 10 ma and on a steady voltage of from 200 to 250 kv The cathode and anticathode are so constructed that they can be replaced in a short time

The tube, which is well illustrated and described by Allibone is mounted so that it is easily manipulated and controlled Many of the important features of this porcelain and steel-enclosed tube with a greater output than that customary for glass tubes are discussed

These continuously evacuated tubes are being developed in many parts of the world where high voltage tubes are pumped with Apiezon oils and are operated with varying degrees of success

GEORGE E BURCH M D

Dosimetry with the Mecapion in Contact Roentgen Therapy S Strauss Strahlentherapie 1936 55, 537

The author briefly describes a modification of the mecapiion adapted especially for use in x ray therapy at very small FSD according to the method described by Chaoul

ERNST A POHLE, M D, Ph D

A Simple Device for Remote Control of Filter and Shutter in Superficial Therapy S Epstein Strahlentherapie 1936, 55, 366

The author describes briefly a shutter attached to the x ray tube which can be operated from the control booth The operator can insert the proper filter or a lead shutter without leaving the control stand A pilot light operating in connection with the device shows when the filter is in place

ERNST A POHLE M D Ph D

Experiences in Manchester with the Metropolitan-Vickers Tube Ralston Paterson Proc. Royal Soc Med, March 1936 29, 449-452

Paterson concludes from his experiences with the Metropolitan Vickers tube that it is a satisfactory and reliable unit The replacement and difficulties that were encountered were rapidly and easily cared for The tube has a high initial cost but a low running cost It is readily manipulated for extremely short or long exposures at varying intensities

GEORGE E BURCH M D

## ARTERIOGRAPHY

Arteriography of the Brain H Urban Wien klin Wchnschr, July 12, 1935, 48, 924-927 (Reprinted by permission from British Med Jour, Dec 7, 1935, p 89 of Epitome of Current Medical Literature.)

The author describes the use of thorotrast in this procedure Under local anesthesia, 10 c.c. are injected into the commencement of the internal carotid artery as quickly as possible, and the x-ray film is taken just before completion of the injection (so quick is the circulation through the brain that a second later the thorotrast is traceable in the veins only) The medium is stored indefinitely in the liver and spleen The arterial injection is painless, causes but a few seconds, stupor and may lead to a transitory disappearance of headaches if present Only the lateral radiograph is instructive, and in it the posterior cerebral artery (coming indirectly from the vertebral) is not shown This artery can be traced by thorotrast injection of the subclavian, the artery being clamped distally and the syringe directed toward the heart through the innominate artery the basilar artery and the posterior cerebral arteries of both sides are injected For comparison in the ordinary procedure the lateral radiographs of both sides should be taken at the same sitting

From an experience of 50 cases Urban concludes that while arteriography is of considerable help in localization of cerebral tumors its chief value is in determining their nature—especially in angiomas aneurysms, and arteriovenous communications behind the orbit

## ARTHRITIS

Roentgenographic Features of Rheumatoid Arthritis Albert B Ferguson Jour Bone and Joint Surg April 1936, 18, 297-300

Rheumatoid arthritis is defined as 'that form of multiple arthritis which begins before the age of 35 years and tends to loss of cartilage and bone at the joints deformity and eventual ankylosis emaciation of the patient, elevation of the sedimentation rate of the blood and positive response to the streptococcus agglutination test'

In the roentgen study of rheumatoid arthritis the hands feet, knees and lumbar spine should be examined in every case The soft tissues should be clearly shown in all cases as certain changes are noted in the soft tissues in the region of the joints and in the relative densities of soft tissues and bone

In the early stages of rheumatoid arthritis the roentgen signs consist of a uniform decrease in density particularly in the hands and feet and the appearance of a fusiform soft tissue mass in the region of the joints especially the phalangeal articulations Later stages of the disease show by roentgen examination evidence of punched-out rounded areas of loss of bone at the junction of the cartilage and bone in the region of the joint Other findings consist of thinning of the car-

tilaginous joint space, and ankylosis With repair, calcareous lipping at the margin of the joint is noted

Because of the great mass of tissue involved in rheumatoid arthritis in the spine, the slight changes found in other joints are not usually noted However, the usual roentgen findings in this locality are slurring of the articular facets, irregular depressions in the articular surfaces of the facets and ankylosis without loss of the intervertebral discs

Rheumatoid arthritis must be differentiated from osteo-arthritis gout, and specific infections of the joints Atrophic arthritis of the toes following gonorrhea is believed to be a special type of rheumatoid arthritis

J N ANÉ, M D

## BIOLOGIC EFFECTS OF RADIATION

The Effect of X-rays on Cleavage in *Arbacia* Eggs Evidence of Nuclear Control of Division Rate P S Henshaw and D S Francis Biol Bull, February, 1936 70, 28-35

Henshaw and Francis studied the effect of irradiation by the x-rays on the cleavage rate of the fertilized eggs of *Arbacia punctulata* They divided their observations into four groups normal eggs fertilized by normal sperm, irradiated eggs fertilized by normal sperm, normal eggs fertilized by irradiated sperm and irradiated eggs fertilized by irradiated sperm The first group was used as controls with which the results in the other three groups were compared The authors found that in the last group the cleavage rate was delayed most and delayed least in the second group They conjectured as to the possible effect of irradiation on the gametes, the effect probably being greatest on the nuclear material and probably to some extent on the centrosomes They claim priority for such observations and conclude that the method employed offers a quantitative estimate of radiobiological reactions

GEORGE E BURCH JR M D

## BONE DISEASES (DIAGNOSIS)

Dystrophies of the Skeleton J F Brailsford British Jour Radiol, September 1935 8, 533-569 (Reprinted by permission from British Jour Med Dec 7, 1935 p 89 of Epitome of Current Medical Literature)

The author has made a study of the serial radiographic appearances of the entire skeleton in cases of dystrophy and as a result defines ten groups namely marble bone disease (Albers Schönberg), osteogenesis imperfecta (Vrolik and Lobstein's types), atelocytic midgets and infantilism (Lorain) achondroplasia (Parrot) chondro-osteo-dystrophy (Brailsford), multiple exostoses or diaphyseal actis (Keith), multiple chondromas (Ollier) unclassified dystrophies including such types as craniocleido-dysostosis acrocephalosyndactylia and arachnodactyly dystrophies as-



sociated with endocrine disorders, and dystrophies associated with other diseases. All these have characteristic radiographic appearances.

Although it is not always possible to obtain evidence of hereditary influences, the indications are so definite in some cases that Brailsford thinks it necessary to consider the probability of there being a recessive factor concerned. None of these dystrophies has been found to possess characteristic histologic findings or specific biochemical reaction and so far these dystrophies have not for the most part been related to endocrine dysfunction. No checking of their development has proved possible except in the case of multiple exostoses and chondromas (which may be treated by local surgical excision), so it is in differential diagnosis that a knowledge of these surgical dystrophies is of most importance.

**Paget's Disease (Osteitis Deformans)** Alexander B. Gutman and Haig Kasabach. *Am Jour Med Sci*, March, 1936, 191, 361-380.

Gutman and Kasabach point out the importance of the roentgenographic examination in Paget's disease. Clinical evidence sufficient to warrant the diagnosis was absent in almost two-thirds of 104 cases. Radiologic study was considered essential for confirmation of the diagnosis as well as for determining the extent and character of the pathology in various bones.

In 14 cases the lesions appeared to be localized to a single area. Early lesions in long bones were confined often to one end of the shaft. In many of the early cases only one side of the pelvis was involved. Since osteitis deformans may become arrested at any stage it would seem hazardous to draw from a single roentgenogram any conclusions as to the activity of bone changes or to predict the course of the disease.

Early skull changes were seen most frequently in the frontal and frontoparietal regions rarely in the occipital regions alone. Involvement of the base of the skull was unusual. Generalized decalcification of the skeleton of the type seen in hyperparathyroidism was not encountered. Varying degrees of osteoporosis were seen associated with co-existing marked arthritis or in cases in which the patient was confined to bed as the result of fractures or deformities. Cyst-like changes were seen occasionally at the proximal ends of the femora or humeri. The bones most commonly involved were the pelvis, skull, femur, humerus, lumbosacral spine, and the tibia.

W. A. SODEMAN, M.D.

**Concerning the Genesis of Madelung's Deformity** W. L. Beder and J. I. Heimschmann. *Fortschr a d Geb d Röntgenstrahlen*, 1935, 52, 595-601.

Two case reports are added to the existing literature on this subject. In addition to the deformities both cases presented endocrine disturbances interpreted as hypophyseal eunuchoidism. The authors want to separate true Madelung's deformity resulting from primary disturbance of bony growth and endocrine dysfunction from pseudo Madelung's deformity induced by trauma, arthritis, osteomyelitis, etc.

H. A. JARRE, M.D.

**Epicondylitis Humeri (Tennis Arm)** Wilhelm Thomsen. *München med Wchnschr*, Nov 8 1935, 82, 1804-1807.

The condition in the light of recent knowledge is unquestionably a myositis of chronic nature, with round cell infiltration about nerve fibrils and vessels and with contiguous periostitis in a percentage of cases. The latter incidence is indeterminate, and probably very often associated in marked cases and contrariwise in the less severe types. It follows that roentgenographic demonstration of periostitis will vary with the above conditions and even when present will not be amenable to demonstration in the very early case. The entity is never a form of arthritis deformans or neuritis, according to the author.

Anatomic and operative studies disclose the extensor digitorum communis muscle to be mainly involved, at its site of insertion. Whether traction or adjacent myositis excites periosteal reaction is a moot question, probably both factors are involved. Curiously, it has been noted that the left arm in right handed persons is frequently involved, which to some degree discredits the excessive trauma theory of etiology. Poor blood supply and fibrositis are strong contributory factors, the author noting this condition in a high percentage of individuals without symptoms. Therapy should be preventive by massage prior to engaging in arduous exercise of certain muscle groups, as in tennis. Conservative treatment consisting of absolute immobilization and heat are employed in the well-established case whereas, massage and heat are efficacious in the very early and late stages of the affection.

WILLIAM R. STECHER, M.D.

**Some Notes on the Diagnosis of Bone Tumors** H. R. Sear. *British Med Jour*, Jan 11 1936, No 3, 914-49-53.

The author discusses the roentgen findings in the various classes of bone tumors. He is of the opinion that errors in diagnosis result from lack of care in interpretation, failure to make use of history and pathologic findings and from lack of experience and knowledge.

The radiologist should have available complete clinical and pathologic laboratory findings. He should feel free to request further laboratory procedures and to make additional x-ray examination if necessary for differential diagnosis. Serial roentgenograms may be necessary to study the progress of a disease although the procedure should be avoided if at all possible because of the greater danger to the patient occasioned by the delay.

For this discussion the bone tumors are classified as follows: (1) changes involving mainly the periosteum or the surface of the cortex; (2) cortical changes; (3) central lesions; (4) composite involvement.

The periosteal tumors included are: (1) secondaries from primary bronchiogenic carcinoma, (2) extra-periosteal fibrosarcoma, (3) secondary neuroblastoma, (4) specific periostitis.

Two types of hypertrophic pulmonary osteoarthro-

pathy have been recognized. One type is the true osteo-arthropathy seen in bronchiectasis etc. and the other type which is seen in bronchiogenic carcinoma. There is also single bone metastasis found in this condition. This is noted at roentgen examination as a localized lesion, with slight to moderate cortical erosion and with definite periosteal reaction arranged in a laculated manner. It is not unlike the soap bubble appearance seen at times in secondary hypernephroma.

Extra periosteal fibrosarcoma is the most benign of all sarcomas and local removal is considered sufficient for its cure. It is characterized by a pressure deformity on the adjacent bone, without erosion.

Secondary neuroblastoma is seen in infancy and the early case is characterized by slight elevation of the periosteum sometimes associated with lifting. The skull and long bones are affected. The history reveals inability of the child to use its legs and the blood count shows a marked decrease in red cells.

Syphilitic bone disease may assume many forms, such as osteosclerosis or primary cortical involvement. However the peculiar 'lace work' type of periostitis also may be noted.

The cortical tumors discussed by the author are (1) hydatid, (2) lymphadenoma, (3) secondary involvements such as hypernephroma.

Hydatid disease in bone is comparatively common in Australia (the author's home) and is noted as the central or cortical type of lesion. The cortical type presents erosion with more or less bone production. Of great value in the differential diagnosis is the eosinophilus and the Casoni test.

Lymphadenoma is seen most frequently in the sternum. It may occur also in the vertebrae, pelvis, skull, ribs and femora. It is characterized by bone erosion and bone production in variable proportions. Of diagnostic importance is its ready response to irradiation therapy.

Secondary or metastatic tumors frequently involve a single bone and may prove difficult to differentiate from osteogenic sarcoma of the osteolytic type. The bone metastasis of hypernephroma may be of the central or cortical types. The cortical type is usually seen in the flat bones. The appearance of such lesions has been likened to 'soap bubbles'.

The central lesions considered are (1) the central type of hydatid, (2) lipid histiocytosis, (3) central cartilaginous masses and tumors and (4) metastatic hypernephroma.

The central type of hydatid extends up and down the medullary cavity and simulates bone cyst. The differentiation is difficult in some cases and pathologic assistance must be obtained.

Lipid histiocytosis has been described by Schüller as the geographical skull and by Gaucher as affecting the long bones. Schüller's and Gaucher's diseases may be seen at times in the same individual.

Central cartilaginous masses and tumors include chondrosarcoma and myxochondrosarcoma which may simulate cystic lesions in bone.

The composite tumors include Ewing's tumor

Paget's disease, lipid histiocytosis, and secondary neuroblastoma.

Ewing's tumor may prove extremely difficult to recognize in some cases. It is frequently confused with osteomyelitis. Early cases of Ewing's show increased density in the affected area. It may have an acute onset with fever, pain and leukocytosis.

Paget's disease or osteitis deformans must be differentiated from secondaries of prostatic carcinoma. Of greater difficulty, however, is the recognition of early sarcoma when it supervenes on a bone affected with Paget's disease.

Gaucher's disease causes thinning of the cortex and a worm-eaten appearance of the long bones. The differential diagnosis must be made from tuberculosis of bones.

Secondary neuroblastomas are usually characterized by the worm-eaten appearance of the long bones and the periosteal reaction with, later, the formation of larger transradiant areas.

J. N. ANÉ, M.D.

## THE BRAIN

Review, Clinical and Pathological of Parahypophyseal Lesions. C. H. Frazier. Surg., Gynec. and Obst., January, 1936, 62, 1, February, 1936, 62, 158. (Reprinted by permission from British Med. Jour., March 14, 1936, p. 44 of Epitome of Current Medical Literature.)

The author records a clinical and pathological review of various parahypophyseal lesions and comments on the extraordinary advances in the surgery of brain tumors during the last forty years. The lesions are classified in eight groups. The first of these includes parasellar aneurysms which are sometimes of congenital origin and sometimes due to arteriosclerosis. Mycotic aneurysms are more common in the cerebral than in the basilar vessels. Two cases are reported in which there were intense headaches and periods of momentary unconsciousness. In both instances the patient died, and at necropsy an aneurysm was located. Tumors of the optic nerves and chiasm are comparatively rare, and can be diagnosed only as a result of specific x-ray findings. When the tumor is small there may be only optic atrophy, field defects and loss of visual acuity. Later headache may develop with signs of hypophyseal dysfunction and characteristic alterations in the sella and optic foramina.

These tumors occur most frequently in children and radical removal is inadvisable on account of the inevitable blindness that would result. The most common location for parasellar tumors is the sphenoidal ridge, and the most usual type of growth is the meningeal fibroblastoma. The most frequent symptoms are the loss of visual acuity, field distortions and homonymous hemianopsia. A case is reported in which recovery followed the excision of the tumor. Surgical treatment in cases of suprasellar pseudo-tumors is most satisfactory. Diagnosis must depend on the visual phenomena: loss of visual acuity, field distortions, hemianop-

sociated with endocrine disorders and dystrophies associated with other diseases. All these have characteristic radiographic appearances.

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W. A. SODEMAN, M.D.

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H. A. JARRE, M.D.

**Epicondylitis Humeri (Tennis Arm)** Wilhelm Thomsen. *München med. Wchnschr.*, Nov. 8, 1935, 82, 1804-1807.

The condition in the light of recent knowledge is unquestionably a myositis of chronic nature with round cell infiltration about nerve fibrils and vessels and with contiguous periostitis in a percentage of cases. The latter incidence is indeterminate, and probably very often associated in marked cases and contrariwise, in the less severe types. It follows that roentgenographic demonstration of periostitis will vary with the above conditions, and even when present will not be amenable to demonstration in the very early case. The entity is never a form of arthritis deformans or neuritis, according to the author.

Anatomic and operative studies disclose the extensor digitorum communis muscle to be mainly involved at its site of insertion. Whether traction or adjacent myositis excites periosteal reaction is a moot question, probably both factors are involved. Curiously it has been noted that the left arm in right-handed persons is frequently involved, which to some degree discredits the excessive trauma theory of etiology. Poor blood supply and fibrositis are strong contributory factors, the author noting this condition in a high percentage of individuals without symptoms. Therapy should be preventive by massage prior to engaging in arduous exercise of certain muscle groups, as in tennis. Conservative treatment consisting of absolute immobilization and heat are employed in the well-established case, whereas massage and heat are efficacious in the very early and late stages of the affection.

WILLIAM R. STECHER, M.D.

**Some Notes on the Diagnosis of Bone Tumors** H. R. Sear. *British Med. Jour.* Jan. 11, 1936, No. 3, 914-49-53.

The author discusses the roentgen findings in the various classes of bone tumors. He is of the opinion that errors in diagnosis result from lack of care in interpretation, failure to make use of history and pathologic findings, and from lack of experience and knowledge.

The radiologist should have available complete clinical and pathologic laboratory findings. He should feel free to request further laboratory procedures and to make additional x-ray examination if necessary for differential diagnosis. Serial roentgenograms may be necessary to study the progress of a disease, although the procedure should be avoided if at all possible because of the greater danger to the patient occasioned by the delay.

For this discussion the bone tumors are classified as follows: (1) changes involving mainly the periosteum or the surface of the cortex; (2) cortical changes; (3) central lesions; (4) composite involvement.

The periosteal tumors included are: (1) secondaries from primary bronchiogenic carcinoma; (2) extra-periosteal fibrosarcoma; (3) secondary neuroblastoma; (4) specific periostitis.

Two types of hypertrophic pulmonary osteoarthro-

## CANCER (DIAGNOSIS)

Malignant Tumors of the Epipharynx S Salinger and S J Pearlman Arch Otolaryngol February 1936 23, 149-172 (Reprinted by permission from British Med Jour May 16 1936 p 81 of Epitome of Current Medical Literature)

In an attempt to clarify the nomenclature of malignant tumors of the nasopharynx the authors record a histopathological investigation of 24 cases. The commonest type in the opinion of three pathologists was transitional cell carcinoma (75 per cent). In three instances the diagnosis of sarcoma was considered but was unanimously approved in only one. Lympho-epithelioma was diagnosed in six cases and it was noted that the uncertainty as regards diagnosis was partly due to the similarity of this growth to transitional cell carcinoma and also to inadequate fixing and staining of the sections. Endothelioma was mentioned once by one pathologist and contested by the two others.

The early and characteristic symptoms of transitional cell carcinoma were found to be painless cervical adenopathy, tinnitus or deafness and pains due to involvement of the first and second branches of the trifacial nerve. In most cases in this series the tumor was found to have originated in the region of the Eustachian tube of the lateral wall of the nasopharynx, thus accounting for the symptoms.

The authors agree that these tumors are not amenable to surgery. Treatment consists of external irradiation by means of x-rays or radium packs associated in some cases with the surface application of radium to the growth. Adequate filtration is utilized to obtain the highest degree of penetration. The total dose is estimated biologically, the aim being to cause complete regression of the growth without permanent damage to the adjacent normal structures.

## CANCER (THERAPY)

Development and Treatment of Cancer *en cuirasse* H T Schreus Strahlentherapie 1936 56, 168

The author states that most cases of cancer *en cuirasse* occur in patients following operation; it is very rarely observed in others. While this type of cancer is usually a most hopeless condition, radiation therapy should be given a trial. The following technique proved of value in the author's experience: 80-100 kv, no filter, 300 r per area, 15 X 15 cm field size, total doses up to 3 600 r. While there are no 5-year statistics available, the preliminary results have been encouraging.

ERNST A POHLE M D Ph D

The Effect of Pre-operative Irradiation in Primary Operable Cancer of the Breast Frank E Adair Am Jour Roentgenol and Rad Ther March 1936, 35, 359-370

Radical surgery followed by post-operative irradiation produces 72 per cent of 5-year cures when the

breast alone is involved by malignancy and 23 per cent of 5-year cures when the breast and axilla are involved. These figures compare with the generally accepted averages of 70 per cent of 5-year cures when the breast alone is involved and 20 per cent when both the breast and axilla are involved, if surgery alone is utilized.

In an article previously recorded the author shows 48 per cent of 5-year cures when the tumor was confined to the breast and no 5-year cures when the breast and axilla were involved in cases in which the entire treatment was radiation, both external and interstitial.

In the present study 117 cases of operable breast cancer, each with positive biopsy, have been treated pre-operatively: 65 cases with 200 kv roentgen radiation and 52 cases by the 4-gram radium element pack. These cases being subsequently operated on after an average interval of about two months. Irradiation caused clinical reduction in the volume of the breast tumor in all cases. The axillary disease showed regression by the pre-operative radiation in only some of the cases. In the group of individuals treated by pre-operative roentgen radiation who were given 1 800 r per portal to each of five fields, 33 per cent showed microscopic disappearance of the breast lesion and 22 per cent disappearance of the axillary involvement. Those treated by the radium pack by 20 000 mc-hr per portal showed complete microscopic disappearance of the breast tumor in 14 per cent and in no case was there complete disappearance of the axillary involvement. With a larger dose of 24 000 mc-hr, 45 per cent showed disappearance of the breast tumor and 13 per cent disappearance of the axillary involvement.

Sterilization of the ovaries in pregnant women with breast carcinoma and in all women under 35 years of age is urged.

The pre-operative radiation treatment of the breast should be tangential to the lung as much as possible in order to avoid radiation pneumonitis and secondary anemia.

J E HABBE M D

Cancer of the Lip A Marin L'Union Méd du Canada January 1936 65, 42-47 (Reprinted by permission from British Med Jour, March 28 1936, p 52 of Epitome of Current Medical Literature)

The author divides cancer of the lip into two distinct types: spinocellular and hasocellular. The latter form has a slower growth and a lower grade of malignancy. It occurs on the upper lip and spreads locally; it then invades and destroys the neighboring and deeper tissues. Distant metastasis never occurs, and development is so slow that ten years may elapse before complications take place. There is no pain and the general condition of the patient remains good. Death is not caused directly but by hemorrhage brought about by the invasion of a blood vessel by meningitis or by erysipelas.

Spinocellular epithelioma involves the lower lip, develops very rapidly and is of high grade malignancy. Metastases are very common and may be found in distant parts of the body. After one or two years the

sia, or a concentric contraction of vision Tumors of Rathke's cleft, hypophyseal stalk tumors and suprasellar fibroblastomas are also described, with illustrative cases

### BREAST (BENIGN)

Roentgen Therapy of the Bleeding Breast P Gibert. *Strahlentherapie*, 1936, 56, 81

The author has observed in his practice eight cases of bleeding breast, which he treated with roentgen therapy. Technique 120 kv, 10 mm Al three areas over antero-posterior breast, axilla, and supraclavicular region, 16 X 16 cm field size at 40 cm FSD 1,600 to 2,000 r in five sittings. One patient has been observed over a period of 11 years and has remained well. Before subjecting any patient to this therapy, malignancy must be definitely ruled out.

ERNST A POHLE, M D, Ph D

### BREAST CANCER

Roentgen Therapy of Advanced Carcinoma of the Breast H Holfelder. *Strahlentherapie*, 1936, 56, 97

The author states that x ray therapy in advanced carcinoma of the breast should be given a trial. He quotes four illustrative case reports, with photographs of the patient before and after treatment. Palliative results were very encouraging, as a matter of fact in several instances the growth disappeared completely. Technique 190 kv HVL<sub>Cu</sub> 1.0 mm, doses of from 6,000 to 10,000 r per series spread over periods of from four to eight weeks, simple fractional method with multiple fields.

ERNST A POHLE, M D Ph D

The Effect of Ovarian Irradiation on the Bone Metastases of Cancer of the Breast Richard Dresser. *Am Jour Roentgenol and Rad Ther*, March, 1936 35, 384-388

In the 5-year interval between 1929 and 1934 59 cases of cancer of the breast with bone metastases have received ovarian irradiation 30 being women under 45 and 29 of post menopausal age. Of the group of 30 below menopausal age nine (or 30 per cent) showed definite regression of bone metastases. These results have encouraged the writer to extend ovarian irradiation to women under 45 years of age even when no bone metastases have developed. The author's technique is 200 kv, 0.5 mm copper 600 r measured in air to one anterior pelvic field 15 X 15 cm and one posterior pelvic field of the same size.

J E HABBE M D

The Treatment of Inoperable Recurrent and Metastatic Carcinoma of the Breast Eugene T Leddy and Arthur U Desjardins. *Am Jour Roentgenol and Rad Ther* March 1936, 35, 371-383

Inoperable carcinoma of the breast is best treated by roentgen therapy using multiple converging beams with a combination of buried radium in selected cases.

Operable recurrences are best treated by operation

supplemented by roentgen therapy the results of roentgen treatment being in every way equal to those obtained with radium. Local recurrence of carcinoma in the field of operation is the most favorable to treat, whereas axillary recurrence in general has the worst prognosis. The commonest type of metastases was to the supraclavicular nodes. Roentgen therapy is recommended but its value is difficult to state. Lung and liver metastases respond poorly but osseous metastases favorably.

There is little evidence of superiority of radium or 200 kv roentgen therapy over 135 kv x rays, in fact, in some lesions the latter appears preferable.

J E HABBE, M D

Indications for Radical Surgery of the Breast Hugh Auchincloss. *Am Jour Roentgenol and Rad Ther*, March, 1936 35, 344-347

Radical surgery in malignant disease of the breast is contra indicated in cases in which the disease has spread beyond the limits capable of being removed by operation. The young individual presenting a tumor with rapid growth with already existing large hard axillary nodes or a lesion already fixed to and involving the chest wall near the sternum or one with much nipple involvement and widespread lymphedema or one in which may dilated veins and beginning skin ulceration are evident—these and certain other combinations may lead one to infer that the case is not suitable for surgery. However in the opinion of the author unless the disease has spread beyond the point where it can be removed the patient should be given the benefit of the doubt and operated upon. The author has seen many cases considered clinically hopeless which were so helped by irradiation that suffering was relieved and even subsequent operation done. Post-operative irradiation is of definite value.

In addition to the usual and perhaps most commonly encountered extension to the axillary glands there are other routes which must also be continuously considered. There are lymph channels which go along the branches of the internal mammary arteries. The internal mammary nodes that communicate with the retro manubrial nodes at the prepericardial nodes near the diaphragm receive much lymph from the breast. Again, lymph channels enter the space between external and internal intercostal muscles. These external intercostal lymph vessels run backward to enter the posterior intercostal lymph nodes in front of the necks of the ribs close to the spine. Still again there are lymphatics communicating between the axilla the skull and the scalp which may account for the frequency of metastases in these last named regions.

The author concludes with a plea for instruction of the laity as to the importance of the woman regularly examining herself for evidence of a lump in the breast. Then she may commonly be able to determine the presence of a pathological mass after she has become skilled in self-examination which the doctor may himself not be able to feel.

J E HABBE M D

1 10,000 in the treatment of inoperable advanced malignant tumors. As many as 35 injections of from 5 to 20 cc each were given subcutaneously intravenously, or intraperitoneally without undesirable reactions. Occasionally arsenic acid (1 10,000) was also injected in doses of from one to two cubic centimeters. If the injections into the tumor itself proved painful, novocaine was added. There is no contra indication to supplementary radiation therapy in cases treated by this chemical method. Although the author has only a few cases to report—he is a private practitioner without hospital facilities—he describes his method in detail and invites others with large clinical material to check his results.

ERNST A. POHLE, M.D., Ph.D.

**Epicrisis of the Irradiated Carcinoma of the Cervix**  
H. Hausding. *Strahlentherapie*, 1936, 55, 387.

Malignant tumors in patients presenting a similar clinical picture may show a great difference in their response to irradiation. Consequently investigators turned toward a study of the histologic structure in order to find a possible explanation for this observation. The author's own investigations are based on the microscopic examination of tissues of 240 cases of squamous-cell carcinoma of the cervix. By a careful correlation of the microscopic picture with the clinical data certain conclusions could be drawn regarding the relation between histologic character and response to radiation therapy. The number of mitoses increased with the number of atypical structures in the tissue. Immature types of neoplasm did not offer a better chance for cure than more mature forms. Neoplasms with a high number of mitoses were slightly more radiosensitive than those with very few mitoses. However no definite relationship could be discovered between response to treatment, percentage of cure, and histologic structure or number of mitoses in the neoplastic tissue. The microscopic picture should, therefore, be used only as one factor in arriving at a prognosis.

ERNST A. POHLE, M.D., Ph.D.

**Results of Radiation Therapy of Carcinoma of the Vulva**  
I. von Kövesligethy Büben. *Strahlentherapie*, 1936, 56, 28.

From 1919 to 1934 cases of carcinoma of the vulva to the number of 59 were seen at the Women's Clinic of the University of Budapest. Of these, 47 were inoperable. After biopsy, special radium applicators were prepared and applied at a distance from the skin of from 0.5 to 1.0 cm., filtered through 1 mm. Pt or its equivalent. The radium treatment was repeated if necessary in six weeks. The inguinal glands were subjected to roentgen therapy, three or four areas were given three times and a total dose of 1500 r was administered (100 kv., 5 ma., 0.5 mm. Zn + 0.5 mm. Al, 30 cm. f.s.d.). Of the 47 patients, 38 with inoperable carcinoma of the vulva could be followed over a five year period. Five remained well after that interval corresponding to 13.1 per cent. One case

was still well 11 years after the treatment. A palliative effect, that is, freedom from symptoms for at least one year, was seen in 30 cases.

ERNST A. POHLE, M.D., Ph.D.

## COBRA TOXIN

**Experiment with Cobra Toxin for Pain Relief**  
Johannes Seiler. *München med. Wchnschr.*, March 27, 1936, 83, 527, 528.

A brief review of the French literature is given, and the claims as to the efficacy of cobra-toxin injection for relief of pain, particularly in carcinomatous metastasis, is discussed. In brief the observers claim marked pain relief, regression of primary tumor, and experimentally, restraint of tissue culture growth. The author was unable to duplicate these results and concluded that in his experience, pain was not relieved and often made worse. Also the regression of primary tumor was so slight as to be negligible. Other local and systemic untoward reactions occurred which were troublesome.

He is unable to explain the marked discrepancy between his own results and those of the French school and particularly Calmette, but suggests that the organic extract he employed could possibly have had insufficient or no substance such as affords the salubrious results claimed.

WILLIAM R. STECHER, M.D.

## CONTRAST MEDIA

**Obliteration of Varicosities Studied in Roentgen Images**  
K. F. Herlyn. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1936, 53, 122-131.

Following a brief review of previous experimentations concerning the roentgenologic demonstration of varicosities, the result of original experiments concerning 50 patients are reported. As obliterating and roentgenologic contrast medium a solution was used of Uroselectan B and invert sugar. The author studied particularly the time during which this medium could be demonstrated in the circulation, the distribution of the medium and the direction of its flow, the mechanism of evacuation and external influences bearing on these phenomena. The results were obtained partly with partly without, compression of the femoral vessels.

H. A. JARRE, M.D.

**Injection of Thorotrast to Determine the Presence and Extent of Subphrenic Abscess**  
K. Heckmann and E. Altenburger. *München med. Wchnschr.*, Nov. 8, 1935, 82, 1800-1802.

Thorotrast injected into a subphrenic abscess not only verifies the provisional diagnosis, but may actually demonstrate its etiology. This procedure is valuable, particularly when a gastro-intestinal study is precluded. The authors consider this method superior to air injection after attempt at complete drainage of the abscess cavity which is generally impossible. The thorotrast by virtue of its radio-opacity and high atomic weight

patient usually succumbs to cachexia marasmus and general infection. Epithelioma of this type arises in the mucous membrane of the lip, and is often preceded by leukoplakia. The ulcerated growth is about the size of an olive. Cancer of the basal-celled type of the upper lip occurs on the skin and develops as a senile keratosis. The growth is small at first and grows very slowly, the glands are never invaded. Treatment of this form of epithelioma when the growth is still localized in the skin, should be by electrocoagulation or radiotherapy. Treatment for growths of the spinocellular type is by radium needles and excision of the glands. If these glands are fixed and inoperable, deep radiotherapy is a palliative procedure. A case is recorded which was cured by radium.

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The Treatment of Malignant Melanoma with Roentgen Therapy at Short Distance. H. Chaoul and K. Greineder. *Strahlentherapie*, 1936, 56, 40.

After a brief discussion of the various treatment methods of malignant melanoma, i.e., surgery, electrotherm knife, irradiation, the authors report 14 cases treated by roentgen rays and observed during the last four years. They emphasize that while this type of tumor has always been considered highly radioresistant in their experience this did not prove to be correct. They used massive doses of roentgen rays produced at moderate potentials and with fairly heavy filtration and at very short distance (below 10 cm). With this technique it is possible to apply from 400 to 500 r per day and total doses of 10,000 r. The clinical data of the 14 cases are given in tabulated form. Although the number of cases is small and in view of the fact that they have been under observation from five months to four years only, no definite conclusions as to the efficacy of the method are drawn. However, the results are quite encouraging if one considers the high malignancy of melanosarcoma and, therefore, this method should be given a trial in suitable cases.

ERNST A. POHLE, M.D., Ph.D.

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The Roentgen Treatment of Malignancy Using Filtration Equivalent to 5 mm. Copper. E. A. Merritt and R. Rhett Rathbone. *Am. Jour. Roentgenol. and Rad. Ther.*, March 1936, 35, 334-343.

For the fifteen months preceding the recording of this material the authors have been using a new filter composed of 1.25 mm. tin, 0.25 mm. copper, and 1.0 mm. aluminum for malignancy therapy using 220 kv., 20 ma. 50 cm. distance, with an intensity of 10 r per minute measured in air. This composite filter has a maximum wave length as defined by Thoreaus of 0.21 Ångström, which is the same maximum wave length as filtered by 5 mm. copper. The effective wave length is 0.086 Ångström. The intensity is 35 per cent greater with this composite filter than with 5 mm. copper filter. It is believed that there is a differential effect on the skin or epidermoid structures as a group in contrast to connective tissue or supporting body structures as the opposite group. Therefore by increasing the filtration there is better protection of the underlying subcutaneous

tissues when giving a lethal skin dose. In cases in which blistering doses are given over large areas (15 × 5 cm. and over), the heavy filtration is necessary to insure healing. Widening of the lethal threshold between skin and subcutaneous tissues is not readily observable in cross firing as, for example, in treating malignancies of the head and neck, since it has been shown that the transmitted radiation is very 'soft' even when high initial filtration is used.

The authors feel that protraction of treatment time in days increases the subcutaneous tissue tolerance but when the time is protracted too long or approximately nine weeks, there is danger of tumor recovery. Hence the daily and total dose must be adjusted so as to exceed the recovery rate or the so-called tolerance dose, which is estimated by the writers to be about 150 r per day to a single area using heavy filtration. For the sensitive malignancies with a relatively high daily dose administered, the tumor may be destroyed in about three weeks' time. However, if the malignancy is relatively resistant the time should be protracted over four to six weeks with lower daily dose and higher total dose.

With the heavy filter now used the skin reaction develops slowly, complete destruction being not observed until the thirty seventh day after beginning treatment. While there is complete vesiculation there is very little edema of the corium and practically no pain. Healing occurs in from six to twelve weeks. The authors cite cases of both superficial and deep seated extensive malignancy treated by this method, with very favorable results extending over several years' post radiation observation, with surprisingly little immediate constitutional or permanent local ill effects.

J. E. HABBE, M.D.

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Post-operative Irradiation Following Radical Operation in Carcinoma of the Cervix. F. Friedl. *Strahlentherapie*, 1936, 55, 457.

The value of x-ray therapy following radical operation (Wertheim) in patients with carcinoma of the cervix is still a debatable question and opinions for and against the procedure have been recorded in the literature. The author presents a material of 111 cases all proved by biopsy. 40 were operated on only and 71 received x-ray deep therapy post-operatively. This consisted of one or two series, one shortly after the operation, the other three months later. Each series consisted of six fields of 10 × 15 sq. cm., applying a skin erythema dose over the entire small pelvis. The 40 cases treated in 1928 by operation only showed 42.5 per cent five-year cure, while the 71 cases treated in 1929 by operation plus radiation showed a 47.8 per cent five-year cure. Although the improvement in results due to the combined method is small, the author believes that roentgen therapy following radical operation in carcinoma of the cervix is of value.

ERNST A. POHLE, M.D., Ph.D.

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Contribution to the Treatment of Incurable Carcinoma. J. Grode. *Strahlentherapie*, 1936, 55, 462.

The author reports his preliminary results obtained with injections of chromic acid ( $\text{CrO}_3$ ) in a solution of

# THE DIAPHRAGM

A Rare Case of Eventration of the Diaphragm W Weng München med Wehnschr, April 24 1936, 83, 693, 694

The author reports an unusual case of marked eventration of the left diaphragm occurring post-operatively from an incision of suppurative cervical lymphadenitis. The paresis of the phrenic nerve was either resultant of damage to the phrenic nerve during the incision, or to cicatricial contracture about the nerve. The degree of relaxation of the diaphragm is noteworthy inasmuch as the commonly employed phrenico-exeresis rarely approaches such a degree. The cause of this, he is unable to explain.

WILLIAM R. STECHER, M.D.

# DOSAGE

The Effect of Roentgen Rays of Different Wave Lengths and Intensity on the Autolytic Ferments in Cancer Tissue A Faragó Strahlentherapie, 1936 55, 481

Cancer cells obtained from human cancer of the breast were suspended in solutions with a pH of 3.8 and 8.0 respectively, because these two values represent the optimal  $C_{H^+}$  for pepsinase and trypsinase. Two qualities of roentgen rays were used: 180 kv, 0.8 mm Cu + 0.5 mm Al and 100 kv, 1.0 mm Al. The respective half value layers in copper amounted to 1.18 mm and 0.13 mm. The action of the ferments is increased following irradiation up to a dose of 2,500 r, after further increase of the dose it is decreased. The wave length of roentgen rays has no influence on this reaction. The effect of radiation is however dependent upon the intensity, higher intensity having a more pronounced effect provided that equal doses are given. In order to determine the mechanism of the observed phenomena, 0.25 per cent solutions of pure ferments were irradiated. It appeared that they are due to a direct effect of roentgen rays on the autolytic ferments.

ERNST A. POHLE, M.D., Ph.D.

The Sensibilization of Roentgen resistant Neoplasms by Means of Short Electric Waves G. Luchs Strahlentherapie 1936 55, 473

This is a preliminary report regarding the combined application of short electric waves and roentgen therapy. The author states that short electric waves do not increase the degree of malignancy in a neoplasm. There are also no injuries to the skin area to be expected from the combined application of roentgen rays and short electric waves. While he is not prepared to state definitely how much benefit may be derived from this combined treatment, he suggests that it be given a trial in suitable cases.

ERNST A. POHLE, M.D., Ph.D.

# ELECTRICAL EFFECTS

Radiation and Electric Charges in the Atmosphere F. Dessauer Strahlentherapie 1936, 55, 614

This is a report rendered by the author before the Thirteenth Congress of Roentgenologists and Radiologists of Czecho-Slovakia, held in Prague in 1935. He analyzes the relation between climate and biologic reactions. The rôle played by electric charges in the air as suggested by the author's researches is discussed in detail. Its clinical application is the inhalation of air charged with negative ions in an attempt to influence beneficially certain pathologic conditions. (For details see the author's book "Zehn Jahre Forschung auf dem Physikalisch-Medizinischen Grenzgebiet," Georg Thieme Leipzig 1931.)

ERNST A. POHLE, M.D., Ph.D.

# EPIDIDYMYIS

Hemangioma of the Epididymis A. L. d'Abreu British Jour Surg, April 1936 23, 858-859

It would seem rather difficult to diagnose pre-operatively this condition from other cystic and inflammatory swellings of the epididymis. A record of the reported case is incorporated in the article along with reproductions of the microscopic sections.

DAVIS H. PARDOLL, M.D.

# EPILATION OF SCALP

The Epilation of the Scalp by Roentgen Rays A. Proppe Strahlentherapie 1936 55, 225

The author has investigated the various methods recommended for epilation of the entire scalp based on clinical observations and mathematical deductions. He comes to the conclusion that most methods in use to day are fraught with danger. The application of five or more fields leads to overlapping and consequently to appreciable overdoses in some areas. The method of Schreus, who uses only four fields and a focal skin distance at least as great as the diameter of the skull (100 kv, 0.5 mm Al, 400 r per field) seems to be the safest procedure and produces uniform results. Photographs showing the scalp of a patient treated by this method are shown in the article.

ERNST A. POHLE, M.D., Ph.D.

Studies of Late Effects Following Epilation by Roentgen Rays Especially Regarding the Mental Development in Children T. Symann Strahlentherapie, 1936 55, 248

During the period from 1917 to 1926 a total of 312 roentgen epilations were carried out at the University Skin Clinic in Düsseldorf. The author conducted a follow up study in order to determine whether or not there were any late injuries in these patients. He was particularly interested to investigate the possibility of an influence of irradiation on the development of the young brain. Fifty three cases were available for study: 33 were treated for tinea, five for favus, eleven for trichophyton, and four had an undetermined



lends itself admirably for outlining the various recesses and dependent portions of the collection. No toxic effects were manifest. By rotating the patient the entire inner relief of the abscess cavity can be visualized and roentgenographically recorded.

A case is presented in which a diagnosis of subphrenic abscess was established, and additional suggestive evidence of an indeterminate density in the vicinity of the gall bladder. Autopsy study revealed the latter density to be a carcinoma arising from the gall bladder which had ruptured and extruded numerous biliary calculi and had invaded the transverse colon to some degree. The latter infectious process accounted for the fecal odor of the aspirated pus. The authors are of the conviction that an earlier examination employing an opaque enema would have depicted definite alteration in the mucous membrane relief pattern at the site of the infiltrating neoplasm, which possibly would have suggested the correct diagnosis.

In evaluating the procedure of thorotrast injection into suspected subphrenic abscesses the authors consider it to be a safe and simple procedure affording information as to the extent of the abscess cavity and possibly its etiology without necessitating the complete drainage of the cavity—which generally is not feasible. The information obtained is an aid to the institution of the proper therapy. This method is advocated for other abscess cavities such as psoas abscess.

WILLIAM R. STECHER, M.D.

**Extravasation of Pycelographic Contrast Media into the Retroperitoneal Connective Tissues.** K. Heckmann. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1935, 52, 601-606.

During instrumental pycelography extensive extravasation of the contrast medium occurred from the renal pelvis into the surrounding fatty capsule and the loosely textured retroperitoneal connective tissue. There was neither an appreciable degree of hydronephrosis nor any serious pyelonephritis. The patient succumbed to a lobar pneumonia. Definite evidence of rupture of the renal pelvis could not be demonstrated at autopsy.

H. A. JARRE, M.D.

**Cholangiography for the Study of Biliary Tract Disease.** J. A. Saralegui. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1935, 52, 571-579.

The author has studied the biliary tract during the last ten years by injection of contrast media into post-operative biliary fistulae. He first reported on his findings in 1930, further in 1933 and 1934. During the earlier investigations lipiodol was used which however was found somewhat objectionable in the bile passages. In later years he has used thorotrast which has proved to be a very satisfactory medium. Eleven excellent illustrations show the value of this method and demonstrate various degrees of dilatation of the common duct with inflammatory changes in the wall, residual calculi in various bile passages, stasis and dysfunction. There can be no doubt that in

persistent biliary fistulae a roentgenographic exploration as practised by this author can be of great help for diagnosis and indication for operative cure.

H. A. JARRE, M.D.

**A Case of Fracture of the Temporal Bone with Air in the Ventricles.** Semsettin A. Üstel. *Röntgenpraxis*, December 1935, 7, 816-818.

According to the literature only 31 cases of pneumatocephalus following fractures have been described. In most of these cases the fracture extended into the middle ear and there was a perforation of the ear drum. In a case described by the author a fracture of the temporal bone extending into the petrous portion was demonstrated and the ventricular system was filled with air and looked like an encephalogram.

HANS W. HEFKE, M.D.

**Experimental and Clinical Investigation Concerning Roentgenographic Demonstration of the Cerebral Surface.** K. Koshimizu. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1936, 53, 25-30.

By sub occipital puncture and following removal of a corresponding amount of cerebro-spinal fluid, small amounts of thoratrast—0.3 c.c. per kilogram of body weight in dogs, 20 c.c. in adult humans—were introduced and roentgenographic records of the skull obtained at various periods thereafter. A very satisfactory delineation of the cerebral fissures thus could be obtained. However, while in animals no serious complications were observed the reactions obtained in two humans were such that the method could hardly be recommended for more general use.

H. A. JARRE, M.D.

## CYSTICERCUS

**Multiple Cysticerci in Man.** Eleonore Schick. *München. med. Wchnschr.*, April 24, 1936, 83, 694-696.

The presence of the larval form of *Taenia solium* (pork tapeworm) in man is rare. The pig is the usual intermediate host for cysticerci; man occasionally usurping that role when ova enter the stomach. The embryos are distributed via the blood stream to numerous organs, particularly subcutaneously and intramuscularly to the central nervous system and the orbit. Symptoms vary according to the site of involvement. The organism reacts by enveloping cysticercus with calcific deposition. Eosinophilia is marked. It is important to obtain stereoscopic roentgenograms of such regions as the skull and the chest to determine whether calcific stipplings are extra or intra-cranial or pulmonically located. The author cites a case of extensive cysticercus involvement of the entire musculature of the body and in addition intra-cranial and intra-pulmonary. No cysticerci were found in the orbit, however. Incidentally this is the first case in which cysticerci were demonstrated within the lung *intra-vitam*. The calcifications are sharply circumscribed and 1.0 × 0.5 centimeter in size.

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## PRIMARY BONE TUMORS IN CHILDREN

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**B**ONE tumors occur in children with a somewhat greater frequency than has been generally supposed, primary malignant bone tumors occurring rather more frequently in them than in adults. Except for the fact that because of the age factor a less satisfactory history can be elicited in children, there is no material difference between children and adults as regards symptomatology, physical findings, diagnosis, treatment, and prognosis of bone tumors.

In 16,000 admissions at the Orthopedic Hospital, 89 bone tumors have been recognized, an incidence of one in 180. To this group of cases were added 28 from the Yale Street Clinic, making a total of 117 cases. Twenty-two, or 18.6 per cent, of these were malignant tumors, while 95, or 81.4 per cent, were benign tumors, the group being divided as follows:

Sarcoma	16
Endothelioma	6
Neurocytoma (metastatic)	1
Osteoma and osteochondroma	73
Giant-cell tumors	8
Bone cysts	8
Enchondroma	4
Odontoma	1
	<hr/>
	117

The general incidence of bone tumors to admissions has been one tumor to 180 admissions, an incidence of approximately 0.5 per cent. There has been one malignant tumor to 888 admissions. The ma-

jority of these were sarcomas, of which there was one case in 1200 admissions. These figures may be compared with those obtained in a large private clinic in which the incidence of sarcoma was one to 4000 admissions. The increased incidence noted in our series is, of course, due in part to the fact that the Orthopedic Hospital is exclusively for patients suffering from bone and joint diseases, but it is also due in part to the fact that it is exclusively for children.

There have been innumerable attempts at classification of bone tumors, as a result of which there is considerable confusion in the literature as to the terminology of these growths. At the risk of adding to this confusion we suggest the following method of classification:

- I Tumors arising from osteogenetic elements
  - (a) Osteoma osteochondroma exostoses
  - (b) Chondromyxoma enchondroma, chondroma
  - (c) Chondromyxosarcoma
    - (1) Primary
    - (2) Secondary
  - (d) Osteogenic sarcoma
    - (1) Osteoblastic
    - (2) Osteolytic
  - (e) Bone cysts
  - (f) Giant-cell tumor
- II Tumors arising from tissues resident in bone
  - (a) Diffuse endothelial myeloma (Ewing's tumor)
  - (b) Myeloma
  - (c) Fibrosarcoma
  - (d) Neurosarcoma
- III Tumors metastasizing to bone

Willis Campbell thinks that all malig-

diagnosis In four patients the hair grew thicker following epilation, in eight it appeared to be thinned out, in one case there was definite atrophy of skin and bone which the author believes was probably due to an error in dosage In eight instances the new hair was darker, in two of a lighter color than before epilation Curly hair grew in 14 children but straightened out after from a year to 18 months One patient, aged two years and ten months at the time of roentgen epilation, has been complaining of headaches and vertigo since One might consider in this particular case an injurious effect of roentgen rays because of the great radiosensitivity of the young growing brain The intelligence test showed figures below normal in 18 patients An analysis of the entire material, however did not offer definite proof that the roentgen epilation affected the intelligence of the treated children

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### GASTRO-INTESTINAL TRACT (DIAGNOSIS)

Pneumatosis Cystoides of the Intestine Erich Forfota Fortschr a d Geb d Röntgenstrahlen 1936 53, 131-139

This paper contains the report of a case of this rare affliction which was originally published by Ruckenstein and Kux Symptoms of a perforated ulcer were so predominant in this patient that the roentgenologic diagnosis of pneumatosis cystoides was not made though the roentgenologic record published contained sufficient material for such a diagnosis Characteristic symptoms are pneumoperitoneum, interposition of characteristically altered intestinal loops between liver and diaphragm, ascites and the characteristic appearance of pneumatotic intestinal loops

H A JARRE, M D

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Fig 2 See text

Fig 3 See text

Fig 4 See text

joint. They are frequently multiple, and are occasionally seen in multiple form in hereditary deforming achondroplasia (Fig 4). Many, perhaps even most, exostoses are of inflammatory or traumatic origin, and, strictly speaking, are not tumors.

*Chondromas* or *Enchondromas* are rather common tumors, arising from cartilage cells (Fig 5). Four of these growths were encountered, two of which occurred in males and two in females. The complaint in every instance was swelling, none complained of pain. In one case the tumor was in a metacarpal, while the other three exhibited multiple growths in the phalanges. One case was recurrent ten years after excision. These tumors are benign, arise in the medulla, grow slowly, expand the bone, and rupture the cortex when they become large enough to do so by pressure. They are hard, round, lobulated tumors, often very large. Certain of these tumors are softer and more cellular, containing some myxomatous elements, and these are often called *chondromyxomas*. They are

occasionally described as arising from the cortical structure of long bones, near their epiphyses, but Geschickter and Copeland think that these are really osteochondromas with very large cartilaginous caps. They occur in the diaphyses of bones near the epiphyses, their commonest locations are the metacarpals, the metatarsals, and the phalanges. They are frequently multiple. It is usually stated that these tumors cause some pain, but our observation is that the first symptom is commonly fracture resulting from rather trivial trauma. From the standpoint of roentgen analysis these are central tumors, expanding the bone, with or without trabeculations, breaking through the cortex by pressure only, and frequently multiple (although Geschickter and Copeland state that they rarely are). All of them occur within the first two or three decades of life. They produce no bone, although callus formation may occur after rupture of the cortex.

They are best treated by excision, but, if too large for complete removal, the



Fig 1 See text

nant osteogenic tumors should be included under the general heading of osteogenic sarcoma, a method which, without doubt, would serve to simplify greatly the rather confused terminology. The prognosis, however, and hence the treatment of osteolytic osteogenic sarcoma is somewhat different from that of, *e.g.*, secondary chondromyxosarcoma, and it may be that the additional qualifying statements needed to emphasize this point would serve to lessen the gain which might result from the simplification hoped for.

#### I TUMORS ARISING FROM OSTEOGENETIC ELEMENTS

*Osteomas* are circumscribed overgrowths of bone which, histologically, cannot usually be distinguished from simple hyperplastic growth of bone. Although strictly speaking the term "osteoma" should be applied only to true neoplasms, in practice all forms of bony overgrowth will be included.

There were 23 of these tumors in our series, distributed as follows

Femur	10	Fibula	1
Tibia	5	Scapula	1
Humerus	5	Mandible	1

The age of incidence was from eight to 19 years, the average age being 13 years. The tumor was just noticed at the average age of ten years and four months, an age which coincides with the beginning of the period of rapid growth.

These tumors are purely productive, and are composed solely of bone tissue. They commonly arise in the cortical portion of the bone, which they do not destroy. They may assume any shape, the rather flat

"table top" type (Fig 1) being common. They grow slowly, do not metastasize, and show no tendency to invasion of the adjacent tissues. These are the characteristics which might be expected in a benign tumor. They cause no symptoms directly, but indirectly they may produce pain by the slipping of tendons or muscles over the bony mass, or they may cause limitation of motion by blocking joints. They should be treated by surgical removal when and if they cause any symptoms.

*Osteochondromas* (Fig 2) are benign productive tumors arising from the precartilaginous connective tissue elements in bone. They do not differ greatly from the osteomas in their symptomatology and objective findings.

Of the 40 cases of osteochondroma in this series the involvement of bones was as follows

Multiple bones	11	Carpal	1
Tibia	10	Fibula	1
Femur	9	Ilium	1
Scapula	6	Vertebra	1

They were equally divided as to sex, and the age at admission was from new-born to 14 years, with an average age of three years. Pain was present in only eight cases. Twenty-two patients underwent excision of the tumor, with recurrence in three cases, a percentage of 13.6. The treatment of choice is excision. There is a moderate tendency to recurrence which may be controlled by post-operative irradiation. Roentgenologically, these tumors exhibit a bony base, arising from an intact cortex, and an irregular surface with multiple translucent areas. These areas and the irregularity of the surface reflect the occurrence of the cartilaginous cap and islands characteristic of this tumor. Osteochondromas may be multiple and are frequently very large. The tumor occasionally undergoes malignant degeneration, resulting in the formation of a secondary chondromyxosarcoma.

*Exostoses* (Fig 3) are merely small osteochondromas. They commonly arise near joints and their cartilaginous tips are always directed away from the nearest

mass late in its course. The first symptom is pain, usually mild at first, but rapidly becoming severe. A certain amount of fever and a moderate leukocytosis is not uncommon. These tumors are extremely malignant and are best treated by amputation. In spite of the fact that they are moderately radiosensitive, irradiation therapy seems to be of little use except as a palliative measure, another evidence of the fact that radiosensitivity and curability are not synonyms.

*Secondary*—These are malignant tumors containing fibrous, myxomatous, cartilaginous, and osseous elements, arising from the site of lesions ordinarily not malignant, *i e*, osteochondromas and exostoses, presumably from embryonal rests within the benign lesion. They occur somewhat later in life than the primary chondrosarcoma, and are not commonly or even very frequently found in children. The history usually extends over several years, the complaints being pain and swelling. These tumors, although malignant, are much less so than the primary growths, and the percentage of five-year cures is considerably higher. Geschiekter and Copeland give the following data concerning five-year cures: primary chondrosarcoma, 5 per cent, secondary chondrosarcoma, 24 per cent.

From the standpoint of roentgen findings, and as a general rule, the presence of the originally benign lesion will be recognized. Superimposed upon it will be found the destructive changes of malignancy with a poorly outlined low density mass infiltrating the adjacent tissues. Areas of new bone formation and areas of calcification may be found in the invading mass of tumor. Malignant degeneration should always be suspected when these occur, or when there begins a sudden "speeding up" of the symptoms or growth-rate of a benign tumor, such as osteochondroma or chondroma. Secondary chondrosarcoma is best treated by amputation. Perhaps intensive irradiation before and after operation would increase the percentage of cures.

*Osteogenic Sarcomas*—These tumors arise

from the malignant degeneration of the osteogenetic elements of bone tissue, and the term should be understood to include only those malignant neoplasms which, in some degree, retain the functions of bone production. There are other malignant tumors of bone arising from tissues resident in bone, *e g*, Ewing's tumor and myeloma, which are in no sense related to the group of osteogenic sarcoma. The still frequently encountered sub-classification of periosteal and medullary sarcoma should not be employed, partly for the reasons given above, and partly because all sarcomas sooner or later involve the periosteum, cortex, and medulla. They occur most commonly in long bones (although none of the bones are exempt) and always near the epiphyseal ends of the bones, the presence of a newgrowth in the central portion of the shaft making it unlikely that the growth is an osteogenic sarcoma. The femur, tibia, and humerus are usually said to be the favorite locations of this lesion. There are 16 cases of osteogenic sarcoma in our series, 10 of which were in females and six in males. The age of admission was from 18 months to 18 years, the average being 12 years. The history concerning the tumor extended over periods ranging from two weeks to four months and the average duration of symptoms was three months. The following bones were involved:

Femur	10	Humerus	1
Tibia	4	Fibula	1

The results of treatment were as follows:

		Living	Dead
Refused treatment	2		2
Amputation	6	3 (one 13 mo after operation, two 4 mo)	3
Coley's toxin	2		2
Irradiation	5		5

The duration of life after the onset of the symptoms ranged between four months and four years, the average length of life after the beginning of the disease being 15 months. One patient underwent amputation three and one-half weeks after the appearance of symptoms, and remained



Fig 5 See text



Fig 6 See text



Fig 7 See text.



Fig 8 See text

either primary or secondary and are among those classified by Campbell as primary and secondary osteogenic sarcomas

*Primary*—It is probable that most of these tumors are diagnosed and classified as periosteal sarcomas, since they are of peripheral rather than central origin, and not infrequently exhibit the rather classical "sun-ray" arrangement of thin calcified plaques. They originate in remains of embryonal cartilage, grow with great rapidity, and tend to encircle the bone (Figs 6 and 7). There is, at least in their early stages, little or no cortical destruction (or at any rate none that is apparent in the roentgenogram), although early cortical destruction is one of the distinguishing features of

surgery should be followed by irradiation therapy. There is a considerable tendency for chondromas to recur. Very large chondromatous tumors, especially those occurring in long bones, should be regarded as potentially malignant, and the bone should be subjected to irradiation after removal of the tumor.

*Chondrosarcomas* and *Chondromyxosarcomas* are malignant tumors which may be

malignant tumors. Their principal x-ray characteristics are their homogeneous low density and their extreme translucency, which has caused them to be described as "invisible tumors." Occasionally small areas of bone formation are seen, or the "sun-ray" appearance referred to above may be noted. These tumors often become very large, and metastasize rather late. The medulla may be invaded by the tumor

demonstrable in the roentgenogram is a slight increase in the bone density. This is followed shortly by the appearance of the

tissues. The common locations are identical with those of the osteoblastic type, and the symptomatology consists of pain,



Fig 12 See text



Fig 13 See text

characteristic plaques perpendicular to the long axis of the bone. An often much emphasized point is the so-called "lipping," a triangular area of ossification at the point of reflection of the periosteum from the normal bone (Fig 11). As a matter of fact, this finding, although frequently present, is rather more common in Ewing's tumor than in sarcoma. The point of origin in the epiphyseal end of a long bone is a point of great importance, and bone lesions, whether destructive or productive, arising in this location should always be regarded with the gravest suspicion, while lesions occurring in the mid-portion of a long bone are likely not to be osteogenic sarcoma.

*Osteolytic Osteogenic Sarcoma*—This tumor, the so-called malignant bone aneurysm of older writers, is an extremely vascular, almost purely destructive neoplasm which is highly malignant (Fig 12). Although frequently described as being of medullary origin it actually arises from the sub-cortical portion of the shaft, probably from the endosteum. It extends into the medulla producing a central area of destruction and early perforates the cortex and periosteum, infiltrating the adjacent

swelling, loss of function, and pathologic fracture. There is commonly a history of some comparatively trivial trauma to which the symptoms are attributed. Local heat, slight elevation of temperature ( $99^{\circ}$  to  $101^{\circ}$ ), and a moderate leukocytosis (10,000 to 12,000) are common findings, frequently leading to an erroneous diagnosis of osteomyelitis. Even fluctuation of the tumor mass may be present, and in one of our cases a grayish fluid, apparently pus, was withdrawn by aspiration, the supposed pus, however, contained no bacteria. The tumor mass may become very large (Fig 12). The following case history affords an example of the ease with which an erroneous diagnosis may be reached.

The patient was a girl, aged 14 years. Two months before admission, she ran two splinters into her left knee, and a minor infection followed. This was cared for by her mother, and the condition healed. Five weeks later a painful swelling of the knee developed. The patient was seen by an irregular practitioner who made x-ray films of the knee and diagnosed the condition as being osteomyelitis. No improvement followed treatment, and eight weeks





Fig 9 See text



Fig 10 See text



Fig 11 See text

well for three and one-half years but died of pulmonary metastasis at the end of the fourth year. The distribution of metastatic lesions was as follows:

Other bones	13
Lungs	4
Mediastinum	2
Lymphatic system	1

Some of the metastases were multiple, the lungs and one or more bones being simultaneously involved.

The first symptom is usually slight pain and swelling and is generally ascribed to some preceding trivial injury. Instead of improving under usual treatment, and within a reasonable time, the swelling increases, frequently becoming fusiform, and the pain grows steadily more severe. The diagnosis is usually made at this point by x-ray examination, biopsy, or both. Mild fever and a moderate leukocytosis are not infrequently present. The subsequent course of an untreated case depends upon the degree of malignancy of the tumor. The more highly malignant growths frequently destroy life before a great deal of local destruction and tumefaction have been accomplished (Fig 8). On the other hand, some tumors metastasize

size comparatively late, giving time for extensive local destruction and for the formation of a huge mass (Fig 9). It is interesting and important to note that osteogenic sarcomas appear most often (a) in the region of most intense bone growth, *i e*, the region of the epiphyseal line, and (b) at the age period when growth is most rapid.

Although, strictly speaking, all osteogenic sarcomas produce some bone, there are those in which the destructive changes are predominant, while others lay down considerable amounts of new bone. The former may be described as osteolytic osteogenic sarcomas, while the latter are properly described as osteoblastic.

*Osteoblastic Osteogenic Sarcoma*—The principal characteristics of this tumor are its sub-periosteal origin, its predominantly productive character, its marked hardness and density to the x-ray (from which it receives its name "sclerosing type"), and the peculiar and characteristic plaques of new bone laid down at right-angles to the cortex. Although mainly productive, destruction occurs in both the cortex and the medulla, causing a mottled appearance of the bone (Fig 10). The earliest change

*Giant-cell Tumors*—These are benign, essentially destructive newgrowths, producing new bone only after fracture, and very closely related to bone cysts. Indeed, it is quite probable that bone cysts and giant-cell tumors are merely variants of the same condition. The name "giant-cell sarcoma," formerly commonly used, and still heard rather frequently, is a misnomer, the tumor being in no sense a sarcoma, but a benign, non-metastasizing neoplasm with a moderate tendency to recur. Although largely a disease of adult life, these growths do occur in children. Of the eight cases in this series, six occurred in girls and two in boys. The age of admission varied from two to 19 years, the average age being 14 years. Half of these patients had had an injury and the tumor was found incidentally in the examination. Giant-cell tumors always arise in the region of an epiphysis, a newgrowth in the central portion of the shaft of a bone will not be a giant-cell tumor. The symptoms are moderate pain and swelling which may become very marked. The treatment depends somewhat on the location of the growth. Resection cures all cases, but is obviously so radical a treatment, accompanied by such severe mutilation, that it is not justifiable for a benign tumor under ordinary conditions. Curettage, particularly when the cavity is filled with bone chips, is a satisfactory method of treatment, but somewhat less so than radiation therapy, which is the method of choice. Proper x-ray therapy will result in cure in about 75 per cent of cases, as compared with about 65 per cent of cures by surgical procedure (excluding resection).

The x-ray findings are rather typical. The giant-cell tumor is located at the epiphyseal end of a bone, asymmetrically placed, purely destructive, and expansile. The cortex becomes paper-thin, finally rupturing from the pressure, as distinguished from the erosive destruction without expansion characteristic of a malignant newgrowth. Trabeculae are common, although these may disappear as the tumor becomes very large. The adjacent joint is seldom,

if ever, involved. No periosteal reaction occurs, a point of great value in differentiation from malignant tumor (Fig. 14).

From time to time there appear in the literature reports of malignant giant-cell tumors, exhibiting metastases. A review of these cases seems to indicate diagnostic errors rather than variations in the behavior of true giant-cell tumors. In spite of these various reports it is likely that we should continue to regard these tumors as benign.

Codman reports a particular variety of giant-cell tumor, a so-called "chondromatous giant-cell tumor," which involves the upper epiphyseal lines and is limited by them. It, therefore, does not extend up to the articular cartilage, and in this it resembles a sarcoma. It lacks the characteristic trabeculae, and is rather sharply demarcated. It is said to occur within the first two decades of life. We have not encountered a neoplasm of this description.

## II TUMORS ARISING FROM TISSUES RESIDENT IN BONE

*Diffuse Endothelial Myeloma*—The diagnosis of "Ewing's tumor" is, of late, made more frequently than was formerly the case, and as our diagnostic acumen increases will be made still more frequently, as this is by no means a rare tumor. Its apparent comparative rarity is probably due largely to the fact that this neoplasm is commonly mistaken for either sarcoma or osteomyelitis, particularly the latter. Ewing's tumor is essentially a disease of childhood, although it is not extremely rare in adults. There are six cases in our series, of which five were in girls and one in a boy. The bones involved were the femur (two cases), the tibia, os calcis, ilium, and humerus (one case each). The ages of these patients ranged between five and 13 years, the average being ten years. Symptoms had existed for periods varying from six weeks to six months. All had been treated by diet, massage and baking, chiropractic, casts, or operation. *In all cases the working diagnosis was osteomyelitis.*

The x-ray findings are not particularly

after the initial injury she was admitted to the Orthopedic Hospital. Her knee was hot, swollen, and tender, the swelling involving the knee and lower third of the thigh. *Fluctuation was present*. On aspiration there was obtained some pus (subsequently found to be sterile). Temperature was 100.6° F, pulse 90. Blood count was red cells, 4,500,000, white cells, 11,400, 78 per cent polymorphonuclears, 1 per cent transitional, 2 per cent large lymphocytes, 19 per cent small lymphocytes. An x-ray examination demonstrated osteogenic sarcoma with metastases to the pelvis. The patient died in eleven months.

The x-ray findings are somewhat confusing, and diagnosis is often very difficult, the most common error being that of confusing this malignant newgrowth with benign giant-cell tumor. The important diagnostic points are the almost purely destructive nature of the growth, its location at the ends of long bones, notably the lower end of the femur, the upper end of the tibia, and the upper end of the humerus, the lack of expansion of the shaft, the early and extensive destruction of the cortex, and the invasion of the soft tissues. Periosteal reaction will be present. It should be remembered that *benign tumors always expand the shaft*, breaking through the cortex only after the expansion has produced a paper-thinness, *that they tend to be symmetrical, and that they do not invade the soft tissues*.

**Bone Cysts**—These are benign, localized, circumscribed, destructive lesions incapable of new bone formation excepting by way of repair following fracture. Generalized cystic degeneration of bone, such as is seen with parathyroid tumor and in osteitis fibrosa cystica, is not included in this discussion, which concerns itself only with solitary cysts. They occur in the metaphyseal portions of the shafts of long bones, the most common sites being in the upper end of the femur, the upper end of the tibia, and the upper one-third of the humerus. They may be present, of course, in any bone. They occur almost entirely during childhood, but since they

very commonly cause no symptoms they may not be discovered until adult life. The symptomless bone cyst is often accidentally discovered, the so-called "latent cyst" is a cyst during this period of inactivity. Approximately one-half of all bone cysts are without symptoms, being discovered only when an x-ray examination is made following some injury. When present at all, the symptoms consist of slight pain or perhaps a lump. Bone cysts respond well to irradiation. The surgical treatment consists of curettage and the packing of the cavity with bone chips. There is a moderate tendency to recurrence.

There are eleven cases in our series, of which five were in the tibia, four in the femur, and one each in the humerus and fibula. The age varied from two to 19 years, the average age being twelve and a half years. One patient, aged two years, had three recurrences within three years.

On x-ray examination there is found a sharply limited area of decreased density, having well-defined outlines and with an absence of the normal markings of bone (Fig 13). The cortex is intact unless the cyst is very large (in which case the cortex may be ruptured by mechanical pressure), the bone outline is normal unless the cyst has grown to such proportions as to expand it, in which case the cortex is very thin, and the enlargement is symmetrical. No new bone production is observed. Trabeculations may or may not be present. These tumors must be differentiated from solitary bone abscess, chondroma, myeloma, and the osteolytic form of osteogenic sarcoma. Solitary bone abscess is almost always found in the tibia, and is usually quite small. The periosteum may be elevated over the lesion. Chondroma is prone to occur in the hands and feet, but except for this difference in location differentiation from cyst is next to impossible. Myelomas and sarcomas have the general characteristics of malignant tumors, *ie*, lack of definite limiting walls, asymmetrical enlargement of the bone, early destruction of the cortex without expansion of the bone, and invasion of the soft tissues.

volved, the whole picture changes and the findings are quite different. An irregular and increasing sclerosis (or rather, appearance of sclerosis) develops, leading, in one of our cases, to the diagnosis of "sclerosing type of osteomyelitis" (Fig 17). The bone was mottled, with small, rather well defined areas of increased density, while the bone as a whole (the os calcis) retained its normal size and shape. No definite breaking down of the cortex could be recognized. In another case, with the growth arising in the ilium (Fig 18), a somewhat similar appearance was noted, but with what appeared to be fibrous strands passing through the involved area, with an appearance not unlike that observed in osteitis fibrosa. Later, this growth invaded the sacro-iliac synchondroses and the sacrum.

The common symptoms are pain and



Fig 16 See text



Fig 17 See text



Fig 18 See text

swelling. In children, a mass is usually felt but not commonly in adults. Pain is at first moderate and transient, becoming very severe as the tumor grows, and ceasing when the growth has broken through the bony cortex. After an interval of freedom from pain, it usually begins again and continues until death or amputation. Moderate elevation of temperature is common, ranging from  $99^{\circ}$  to  $103.4^{\circ}$ , usually from  $100^{\circ}$  to  $101^{\circ}$ . Local redness and swelling, with increased local heat, are regular find-

ings, and there is ordinarily a leukocytosis of from 10,000 to 14,000 white cells. A significant diagnostic point is that the increase is principally in the lymphocytes, the polymorphonuclear cells remaining unchanged. Nearly all cases have a history of injury. Just what significance should be attached to this is doubtful. The disease is essentially one of childhood, and children injure themselves constantly. The injury, therefore, may easily be coincidental. Moreover, it is quite possible that a trivial

characteristic (except with involvement of the shaft of a long bone, which produces fairly regular findings), and vary with the

surrounding bone. At the point of reflection of the periosteum from the uninvolved portion of the shaft, some calcification oc-

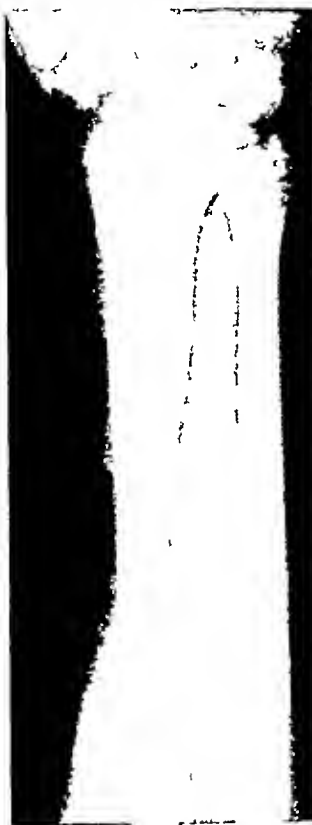


Fig 14 See text



Fig 15 See text

kind of bone involved, and, to some extent, with the location in the bone.

(a) *Ewing's Tumor of Long Bones*—The earliest change which may be observed is a slight increase in the density of the medullary cavity. This is followed by periosteal reaction which results in the formation of thin layers of density parallel to the long axis of the shaft, the so-called "onion-skin" appearance (Fig 15). Irregular areas of decreased and increased density appear in the cortical substance, and expansion begins, assuming an elliptical shape. These irregular areas of increased or decreased density represent areas of destruction and of replacement of bone by small masses of compact tumor tissue which is of greater density than the

curs, producing the "lipping" so commonly described as a characteristic of bone sarcoma. At this point in the development of the tumor, the bone begins to exhibit a "moth-eaten" appearance, although it is difficult to demonstrate any definite breaking down of the cortex. In one case in which, after autopsy, the pathologist described the tumor as a reticulo-endothelioma (Fig 16), the x-ray findings were quite different, the growth being purely osteolytic with no periosteal reaction, and with only an apparently homogeneous area of destruction visible in the roentgenograms. Such a variant must be given some consideration before Ewing's tumor may be excluded in differential diagnosis.

When the irregular or flat bones are in-



Fig 19 See text

tion method Under no circumstances should surgical interference with the tumor itself be attempted These tumors are extremely sensitive to irradiation, which is probably the method of choice Certainly the disappearance of the tumor can be effected as readily as by amputation, and, of course, without mutilation Unfortunately, metastases are prone to occur early and the subsidence of the tumor is not tantamount to cure of the patient Several cases have been reported as living and symptom-free four or more years after amputation

*Myeloma*—It is very doubtful that this lesion occurs in children We have encountered no cases of it, and reference to the literature offers no very convincing evidence of its occurrence Although essentially a disease of later life, it occurs occasionally in young adults A few cases of single myeloma have been reported, but they are not extremely well authenticated, and may well represent diagnostic errors Whether or not such cases do occur the fact remains that the characteristic form



Fig 20 See text

of the disease exhibits many tumors, representing multiple myeloma It is a very rare tumor, Geschickter and Copeland placing its incidence at 0.03 per cent of malignancies The characteristic locations are the ribs, sternum, spine, clavicles, and pelvis (Fig 19) Involvement of the skull (Fig 20) is not infrequent, and when present is quite characteristic in its x-ray findings The number of tumors present is very great, and the growths vary in size from a pinhead upward most of them will be between 0.5 and 1.5 centimeter in diameter Pathologic fracture occurs, but is surprisingly infrequent when the extent of bone involvement is considered Sometimes one sees a vertebra so filled with myeloma that it casts a sort of "ghost shadow" in the roentgenogram but without alteration in its outline and with no compression present The predominating symptom is pain, trivial at first, but becoming agonizing—probably more severe than that occurring in any other tumor Involvement of the spine may be followed by paraplegia resulting from compression of the cord by tumor masses Loss of weight, cachexia, and debility are of regular occurrence A classical finding is the presence of the Bence-Jones bodies in the urine It must be remembered, however, that they do not appear in every case, and that they are sometimes present from various causes Metastasis to other organs occurs, although not regularly There are no characteristic

injury which would ordinarily pass unnoticed may mark the beginning of pain in a tumor and so be closely connected with the growth in the minds of both patient and physician. There seems to be no really sound reason for believing these tumors to be related to trauma.

The principal diagnostic error is in confusing Ewing's tumor with osteomyelitis, an error which occurs so regularly as to be the rule. Differentiation is, in fact, difficult, sometimes even with biopsy.

The important differential points are the following:

Ewing's Tumor	Osteomyelitis
Temperature Usually 99° to 100°, may go higher as high as 103.9° in one case	High—102° to 105°
Leukocyte count 9,000 to 11,000 rarely higher	10,000 to 15,000 or higher
Differential count Polymorphonuclear cells—normal or decreased Lymphocytes—increased	Polymorphonuclear count—increased
X-ray findings Appear early	No demonstrable early changes
X-ray treatment Followed by improvement promptly	No change in symptoms
Aspiration biopsy May enable positive diagnosis	
Sequestrum Absent	Present—later
Periosteum Stripped with 'ipping' at point of reflection	Intact unless broken through as window for pus drainage

Two short case histories will well illustrate the difficulties encountered in the diagnosis of this neoplasm.

A girl, aged 14 years, was admitted for lameness in the left foot. Examination showed a swollen, red, hot, tense heel, extremely tender, which caused constant pain. Blood count 5,000,000 red cells, 12,600 white, with 72 per cent polymorphonuclear cells, 8 per cent large lymphocytes, and 20 per cent small lymphocytes. On the next day the white count was 13,400, and on the following day 16,050. X-ray examination (Fig. 17) showed an apparent sclerosing process, with the cortex intact. Clinical diagnosis was osteomyelitis, sclerosing type. At operation, the bone was found to be hard and indurated, and filled with grayish

"pus" and soft gelatinous material. Culture showed the "pus" to be sterile, and tissue section established the diagnosis of Ewing's tumor. The pain and swelling were relieved promptly by x-ray therapy, but the patient died three months later with widespread metastases.

A girl, aged 11 years, was admitted complaining of a painful left hip of six months' duration. Examination showed local heat, redness, and swelling of the left hip and left iliac region. The temperature ranged between 99° and 103.4° F, the pulse was from 90 to 150. The blood count showed 3,900,000 red cells, and 14,400 white cells of which 84 per cent were polymorphonuclears, 14 per cent small lymphocytes, and 2 per cent transitionals. One week later the red cell count was 3,250,000, white cells 12,700. Clinical diagnosis was infectious osteitis with cystic changes. At operation yellowish "pus" was found, with much brownish-yellow gelatinous material in the bone. The x-ray findings (Fig. 18) closely resembled those of the case described above. The "pus" was sterile. Tissue sections showed typical Ewing's tumor. Response to x-ray therapy was prompt and gratifying, but death from widespread metastases followed in three months.

These two cases are cited, not because they are at all remarkable, but as an example of the errors one may so easily fall into, and as an illustration of the findings that so well explain the errors. Bloodgood's rule should always be remembered. It is that, in the presence of a destructive bone lesion not known positively to be inflammatory, consider the lesion as malignant and irradiate it. Had this rule been followed in the two cases cited, the prompt relief which followed would have served as a deciding diagnostic factor. To be particularly noted is the occurrence and the degree of temperature and leukocytosis, both of which simulate the findings expected in osteomyelitis. The history of the case is of the utmost importance. Biopsy should be made in every suspected case, preferably by the aspira-

are very insensitive to irradiation, and the percentage of cures is extremely low

The extreme difficulty of correctly diagnosing a fibrosarcoma is illustrated by the following case history

A boy, aged seven years, was admitted complaining of a growth in his right forearm, present for six months. Three years previously he had thrust his right forearm and hand into an electric wringer, but x-ray examination revealed no fracture. When last seen in the posture clinic of the hospital, one year before admission, no newgrowth was present in the right forearm. Examination showed a hard mass measuring  $1 \times 4$  cm in the flexor surface of the right forearm on the radial side. There were numerous dilated veins overlying the mass, and a flexion contracture was beginning. X-ray examination showed a productive lesion involving the radius, with no definite bone destruction (Fig 21). Biopsy was performed and the pathologist's opinion was that the growth was a benign fibroma.

The tumor was excised, and recovery was uneventful. Two years later the child returned with a recurrence.

The majority of the staff believed the tumor to be, or to have become, malignant, but as there was a diversity of opinion sections and roentgenograms were submitted to several authorities.

Bloodgood and Willis Campbell thought that the tumor was benign, Crowell, Codman, and Geschickter held that it was malignant. Under x-ray therapy, about 25 per cent reduction in the size of the mass was secured. The total time now elapsed is six years since the occurrence of the tumor, and although its exact nature is still in doubt, the clinical course (the child is in good health) makes it likely that the tumor is non-malignant in character.

This case is cited only to show how completely even extraordinarily competent men may disagree in diagnosis, and how difficult the exact classification of certain tumors becomes.

### III TUMORS METASTASIZING TO BONE

Since this discussion is concerned only with primary tumors, Group III will not be considered here.

#### CLINICAL EXAMINATION

(1) *History*—It is almost impossible to lay too much stress on the value of a proper history, but unhappily no phase of case study is so regularly slighted. It seems trite to point out that a hard swelling which has been present for several years is very unlikely to be a malignant tumor, or that a hot, red, swollen, painful, and tender leg of one week's duration is apt to be an inflammatory lesion, yet these elementary observations are all too frequently not made. Inquiry should be made into the age and occupation of the patient, since certain tumors have a predilection for certain age-groups. Is there anything suggestive in the family history? Have there been recurrent attacks of pain or swelling? Has the patient lived elsewhere (*e.g.*, in the tropics), and, if so, where? What diseases has the patient had? Are the parents syphilitic? Inquiries of this nature will naturally suggest themselves to the careful examiner. The investigation of the present complaint must include not only the manifest symptoms, but the character of their onset, the time of onset, the history of trauma, if any, the method of progression of the symptoms, the character of the pain, and such variations as increased pain at night. Inquiries at first sight unrelated must be made as to chest symptoms, such as cough, abdominal symptoms, as diarrhea, melena, etc., since such findings may be the first clue to the metastatic lesions of malignancy. Has the patient had related symptoms previously? Are there any past injuries? Are the present symptoms new or are they a reappearance of previous symptoms?

(2) *Examination*—This should not be limited to a perfunctory inspection and palpation of the affected part, but must be complete. Are there nodules in the scalp or in the calvarium? Are the eye move-



blood changes, anemia is common, as might be expected. The x-ray findings are fairly characteristic. The location of

Fibrosarcomas and neurosarcomas are rare tumors. Only one occurs in this series, and because of its rarity, is described in

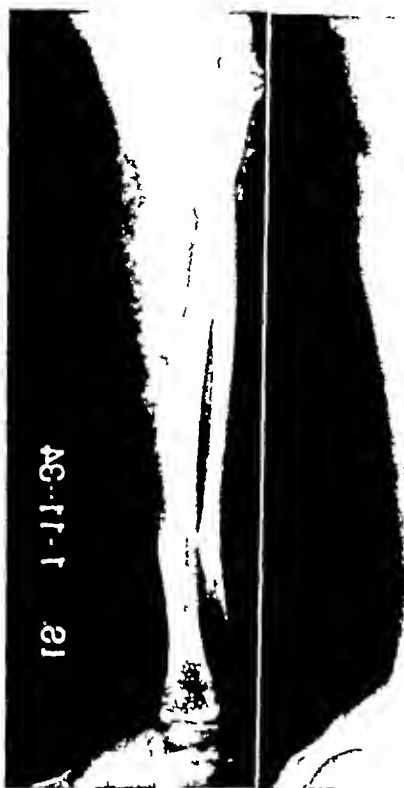


Fig 21 See text



Fig 22 See text.

the tumors in the ribs, sternum, or spine at once suggests myeloma. The pelvis and skull are not infrequently involved, and the long bones may also be affected. The characteristic lesion is a punched-out area of destruction, with no effort at production demonstrable. The number of tumors present in a given bone may produce a mottled appearance, and they frequently become confluent. In the vertebræ, there may be collapse and kyphos, or the vertebral body may retain its contour without deformity. The skull, when involved, exhibits multiple punched-out areas of destruction, commonly in the anterior portion of the skull. The treatment is purely symptomatic and palliative. X-ray therapy, although not curative, has great palliative value and should always be employed.

detail. Properly speaking, these new-growths are not bone tumors, but are neoplasms of fibrous or nerve tissue which invade bone. The typical complaint is of pain of rather long duration, swelling, and decreased function of the part. The x-ray findings are not at all characteristic, consisting largely of bony destruction from without inward, and usually with a visible mass. Diagnosis is very difficult, even when tissue sections are made.

Fibrosarcoma is of a low degree of malignancy and the percentage of five-year cures following amputation is very high. These tumors are not very sensitive to irradiation, but when they involve a part not amenable to amputation, local excision and irradiation therapy will serve to prolong life.

The neurosarcomas are highly malignant,

an infallible one of making a diagnosis. Many times it will be impossible to establish one or more of the necessary points, but

over-production of bone tissue. Since carcinoma, for example, is composed of epithelial tissue and is incapable of bone

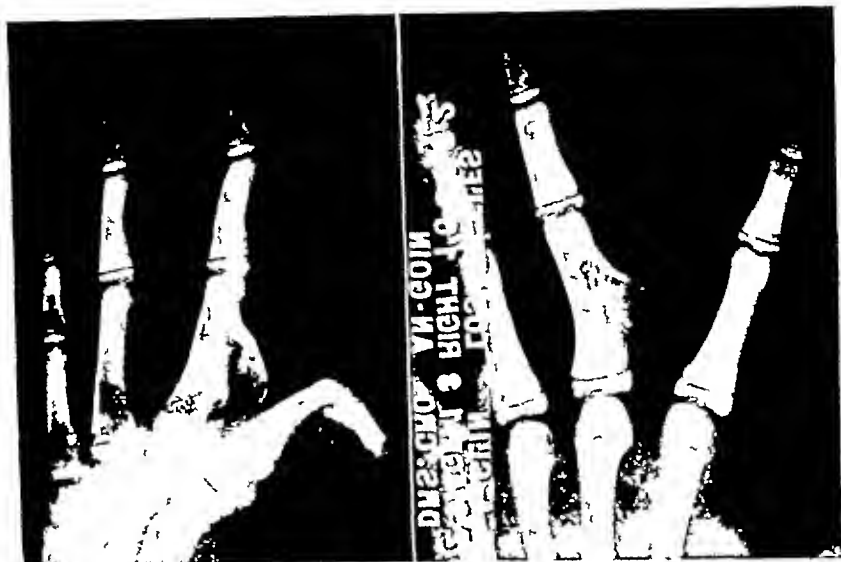


Fig 25 See text

as a sort of schematic outline of procedure it has some merit.

There are only two possible changes in bone which may be recognized by roentgen examination, *viz* bone destruction and bone production, and all changes in the structure of bone consist of one or both of these changes. Since certain bone tumors, *e g*, osteomas, are purely productive growths, and since certain other new-growths, *e g*, cysts, are purely destructive growths, it follows that a new growth of bone which is purely productive cannot be a cyst. Hence the first point to consider in the analysis of bone tumor is whether the process is a destructive one, a productive one, or represents a combination of these two changes.

The purely destructive bone tumors are

Metastatic carcinoma

Multiple myeloma

Endothelioma

(a) Diffuse endothelial myeloma (Ewing's tumor)

(b) Reticulo-endothelioma

Certain types of osteogenic sarcoma

Chondrosarcoma

Bone cysts and giant-cell tumors except after fracture

If we now commence the analysis of a rather simple new growth of bone (Fig 1), we find that the changes present consist of

production, the tumor obviously cannot be carcinoma. In a like manner (that is, by eliminating those tumors which do not produce bone), all of the tumors of the above group may be excluded except osteogenic sarcoma. Thus by application of a single point the exclusion from consideration of a group of bone tumors has been accomplished.

The productive bone tumors are

Osteoma

Osteochondroma

Certain types of osteogenic sarcoma

Chondromyxosarcoma

Cysts and giant-cell tumors after fracture

It is important to distinguish between bone production and simple calcification, on one hand, and between bone destruction and the presence of translucent areas (Fig 22), on the other. One must also remember to distinguish between destruction of bone by intrinsic process and bone destruction by extrinsic lesion pressure (Fig 23), and between bone production and the replacement of bone by masses of tumor tissue of great density (Fig 24).

One may, of course, find bone destruction and bone production in a single

ments normal? Is exophthalmos present? (Remember that bone tumors can as well occur in the skull, and particularly the

biopsy should be performed only between two tourniquets, preferably with an electro surgical cutting unit, and the surgeon



Fig 23 See text



Fig 24 See text

orbit, as elsewhere) Examine the neck for palpable glands, remembering the so-called "sentinel gland" in the left neck Examine the chest and the abdomen, bearing in mind that a primary tumor is occasionally located or identified only by finding metastases The spine must be examined for kyphos, muscle spasm, areas of rigidity, contour, and the presence of tender points Rectal examination should be made if any masses can be felt or are suspected in the pelvis Finally, the affected part is to be examined, noting the location and character of the swelling, local heat, redness, tenderness, crepitation, hardness, irregularity, and fluctuation Is the swelling symmetrical or one-sided? Is it a spherical mass or fusiform? Is motion of an adjacent joint interfered with? If so, may passive motion be performed? Are the reflexes normal?

(3) *Tissue Examination*—Biopsy by the aspiration method may be performed safely, and usually satisfactorily An attempt should be made to secure tissue from several planes of the growth Open

should be prepared to perform amputation if, after frozen section, malignant disease is revealed

(4) *Roentgen Differentiation*—The recognition of a bone tumor and its subsequent classification constitute an enormous diagnostic problem which may not be solved by roentgenologic examination alone The clinical history, the symptoms, the physical findings, and a tissue examination are essential to a complete and proper diagnosis Nevertheless, the x-ray examination is an extremely important factor, probably the most important single factor of the entire diagnostic procedure Because of the infinite number of variations that may be present in a tumor it is impossible to recognize these growths by their characteristic x-ray appearances, or by mental comparison with some other known tumor, and all attempts at classification by such methods are inevitably doomed to failure The first requirement for the roentgen differentiation of a bone tumor is a simple, logical plan of analysis of the tumor The method here presented is by no means

an infallible one of making a diagnosis. Many times it will be impossible to establish one or more of the necessary points, but

over-production of bone tissue. Since carcinoma, for example, is composed of epithelial tissue and is incapable of bone

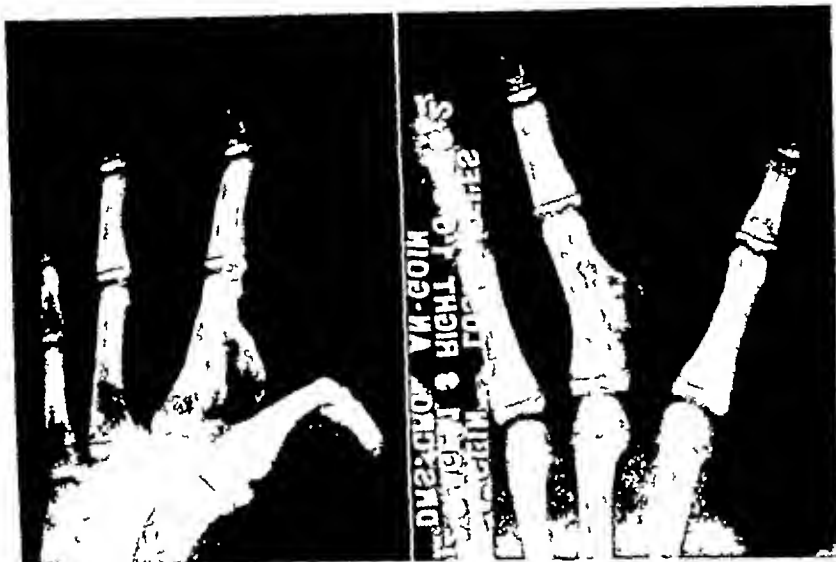


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The purely destructive bone tumors are

- Metastatic carcinoma
- Multiple myeloma
- Endothelioma
  - (a) Diffuse endothelial myeloma (Ewing's tumor)
  - (b) Reticulo-endothelioma
- Certain types of osteogenic sarcoma
- Chondrosarcoma
- Bone cysts and giant-cell tumors except after fracture

If we now commence the analysis of a rather simple newgrowth of bone (Fig 1),

production, the tumor obviously cannot be carcinoma. In a like manner (that is, by eliminating those tumors which do not produce bone), all of the tumors of the above group may be excluded except osteogenic sarcoma. Thus by application of a single point the exclusion from consideration of a group of bone tumors has been accomplished.

The productive bone tumors are

- Osteoma
- Osteochondroma
- Certain types of osteogenic sarcoma
- Chondromyxosarcoma
- Cysts and giant-cell tumors after fracture

It is important to distinguish between bone production and simple calcification, on one hand, and between bone destruction and the presence of translucent areas (Fig 22), on the other. One must also remember to distinguish between destruction of bone by intrinsic process and bone destruction by extrinsic lesion pressure (Fig 23), and between bone production and the replacement of bone by masses of tumor tissue of great density (Fig 24).

One may, of course, find bone destruc-

lesion, as in many of the osteogenic sarcomas (Fig 11)

We have now established a single point, *viz* the productive or destructive nature of the tumor as a method of approach to the analysis of the tumor and may proceed with the consideration of a second point. Does the tumor originate in the medulla or the cortex of the bone? Tumors arising from the cortex of the bone are

Osteomas

Osteochondromas

Some of the sarcoma group including chondrosarcomas and chondromyxosarcomas

Cysts (rarely)

Chondrosarcoma and chondromyxosarcoma may simulate medullary origin, although they are actually of peripheral origin

Tumors originating in the medulla are

Carcinomas and other metastatic newgrowths

Myelomas

Chondromas

Cysts

Giant-cell tumors and some of the sarcoma group

If we now return to the original example (Fig 1) which was found to be a productive tumor, and note that it arises from the cortex of the bone, we will have limited the possibility of differentiation to osteoma and osteochondroma. A growth arising in the cortex could not be carcinoma, since the circulatory mechanism bears the metastases to the medulla. Since cysts rarely originate in the cortex, a growth arising there is very probably not a cyst. Reasoning along these lines may be carried on until a group of possible tumors has been narrowed down to a much smaller field of possibility. Of course, the exact origin of a newgrowth is not always easily determined, when possible, more strength has been added to the diagnostic structure.

The third point of analytical approach is the condition of the cortex. Is it intact or has it been destroyed? If there is cortical destruction, is it because the growth has ruptured it mechanically, by its sheer size, or has the cortex been eroded without expansion? Benign tumors, because of their slow growth, expand the shaft of the

bone but do not perforate the cortex until they do so by simple pressure, malignant tumors grow rapidly and erode the cortex very early.

The fourth point for consideration is the presence or absence of invasion of the soft tissue. Remember that although benign tumors may displace tissue they never invade it, while all malignant tumors invade adjacent tissue.

By way of illustration we may now apply this method to the differentiation of the tumor shown in Figure 25. This is purely a destructive tumor originating in the medulla of a phalanx, with marked expansion of the cortex and cortical rupture. There is no evidence of new bone production and no invasion of the soft tissue. The purely destructive tumors are

Cysts and giant-cell tumors

Carcinoma

Myeloma

Chondroma and some of the sarcomas

Although the cortex of this phalanx is ruptured it has not been eroded and the tumor broke through it only after the cortex had expanded to paper-like thinness. The absence of any invasive changes eliminates the malignant tumors. The phalanges are a favorite site of multiple chondromas and classification of this tumor as chondroma would be supported by the presence of a similar tumor in the middle phalanx of the same finger. Any tumor may be analyzed in a like manner, although the solution of the problem is not always so readily found.

#### CONCLUSIONS

(1) Primary bone tumors are common in children, and are, indeed, probably essentially lesions of childhood.

(2) They occur most frequently in the regions of bone when growth is most intense, and at the chronological age when growth is most rapid.

(3) The findings in 117 cases of bone tumors in children have been described, and the treatment employed at the Orthopedic Hospital has been indicated.

# ASBESTOSIS A ROENTGENOLOGIC REVIEW OF 71 CASES

By J RUSH SHULL, M D , Charlotte, N C

**A**SBESTOS has been used in industry for centuries. It would seem that the pathologic action of this dust in the lungs would have been recognized before 1900, when Murray, in England, performed an autopsy on such a case. This autopsy was performed on a man, the last of 11 men who had begun work together in an asbestos plant in 1890. Murray did not report his findings until 1906. Probably the first case in English medical literature to be definitely proved as asbestosis, was reported by Cooke in 1924. This patient had tuberculosis as a complication.

Little attention has been paid to this form of pneumoconiosis in the American literature until 1928, when the "Journal of the American Medical Association" commented editorially on Cooke's report and suggested that this condition deserved more consideration than it has been given. The first case reported in America was by Mills, in 1930. Since then many individual case reports, or small groups of cases, have been brought to our attention, but no large series from which a comprehensive study can be made has appeared.

Asbestosis may be defined as a disease of the lungs caused by the inhalation of asbestos dust and fiber. It is classified as a pneumoconiosis and is characterized roentgenologically by an early interstitial fibrosis with progression into a terminal diffuse fibrosis. This fibrosis begins primarily in the bases of the lungs, involving the peribronchial structures. The parenchyma of the lungs is comparatively uninvolved. As the disease progresses there develops a filmy, hazy appearance of the lung-fields which has been aptly described as a "ground-glass appearance." The right side of the heart is frequently enlarged in

TABLE I —PULMONARY ASBESTOSIS

Percentage of Cases Having	16 Slightly Advanced	35 Moderately Advanced	20 Markedly Advanced
Right sided cardiac hypertrophy	37.5	62.8	95.0
Pericardial and pleural thickening	0	28.6	45.0
High left diaphragm	12.5	48.6	80.0
Emphysematous type of chest	6.3	65.7	95.0

CHART I —PULMONARY ASBESTOSIS SLIGHTLY ADVANCED CASES

	Name	Age	Color	Sex	Years' Exposure	Tuberculosis Present	Cardiac Hypertrophy Right sided	Pericardial and Pleural Thickening	High Left Diaphragm	Trachea Displaced	Emphysematous Type of Chest	Comments
1	W I W	28	W	M	4	-	Slight	-	+	-	-	No 12, R L D died of pneumonia 15 months after examination III only three days
2	C W *	34	W	M	2 1/2	-	-	-	+	-	-	
3	S E T	25	W	M	2 1/2	-	-	-	-	-	-	
4	J S *	24	W	M	4	+	-	-	-	-	-	
5	B B R	28	W	M	4	+	-	-	-	-	-	
6	K T *	26	W	M	2	+	-	-	-	-	-	
7	L B H *	26	W	M	9	+	-	-	-	-	-	
8	J H *	24	W	M	1 1/2	-	Moderate	-	-	-	-	
9	J G	44	W	M	10	-	Moderate	-	+	-	Yes	
10	J I F *	49	W	M	6	-	-	-	-	-	-	
11	W F	38	W	F	13	-	-	-	-	-	-	
12	R I D	46	W	M	12	-	Slight	-	-	-	-	
13	T J C *	36	W	M	8	-	Slight	-	-	-	-	
14	L I B	34	W	M	2 1/2	-	-	-	-	-	-	
15	I M	23	W	F	4	-	-	-	-	-	-	
16	C B J	30	W	M	5	-	Slight	-	-	-	-	

Re-examined 15 months later  
 \*\* Healed military

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We have now established a single point, *viz* the productive or destructive nature of the tumor as a method of approach to the analysis of the tumor and may proceed with the consideration of a second point Does the tumor originate in the medulla or the cortex of the bone? Tumors arising from the cortex of the bone are

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Carcinoma  
Myeloma  
Chondroma and some of the sarcomas

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(2) They occur most frequently in the regions of bone when growth is most intense, and at the chronological age when growth is most rapid

(3) The findings in 117 cases of bone tumors in children have been described, and the treatment employed at the Orthopedic Hospital has been indicated

patient, using a skin-target distance of 72 inches. The same technic was meticulously observed in each case, so that films of good contrast and equal exposure could be obtained for comparison. A number were also examined roentgenoscopically.

Fifty-six were white males, six were white females, and nine were negro males. The average age was 34.4 years and the time of exposure varied from 16 months to 21 years.

In eight recognized cases of tuberculosis



Fig 1

Fig 2

Fig 1 Case 3756 Examined on Dec 3 1934, white male aged 49 years. Patient was exposed six years, no complaints. Early type of asbestosis.

Fig 2 Re-examination made on Feb 15 1936. There is slight improvement.

### CHART III —PULMONARY ASBESTOSIS MARKEDLY ADVANCED CASES

	Name	Age	Color	Sex	Years' Exposure	Tuberculosis Present	Cardiac Hypertrophy Right sided	Pericardial and Pleural Thickening	High Left Diaphragm	Trachea Displaced	Emphysematous Type of Chest	Comments
1	P S	36	W	M	10	—	Moderate	—	+	—	Yes	No 3 S G died three months after examination of an acute fulminating tuberculosis. Autopsy reported in text.
2	C H S*	33	W	M	11½	—	Slight	+	—	—	Yes	
3	S G	30	C	M	8	—	Moderate	—	—	—	Yes	
4	R W	40	W	M	8	—	Slight	+	—	—	Yes	No 5 P J V, died one month after examination. Autopsy reported.
5	P J V	55	W	M	20	—	Advanced	+	+	—	Yes	
6	G W C	38	W	M	13	—	Slight	—	+	R	Yes	
7	G H	36	W	M	9	—	Moderate	+	+	—	Yes	No 6 G W C is in sanatorium with tuberculosis.
8	S P	36	W	M	6	—	Moderate	+	+	—	Yes	
9	E A	26	C	M	8	—	Moderate	+	+	—	Yes	
10	C G*	34	C	M	9	—	Moderate	—	+	—	Yes	No 16 W E G had pneumonia four months after examination. Recovery.
11	I B	31	W	M	6	—	Moderate	—	+	—	Yes	
12	L B J*	35	W	M	8	—	Moderate	—	+	—	Yes	
13	C Mc N	47	W	M	10	+	Slight	+	+	R	Yes	
14	T F E	50	W	M	6	—	Moderate	—	+	—	Yes	
15	A J H*	37	W	M	10	—	Moderate	+	+	—	Yes	
16	W E G*	38	W	M	8	—	Slight	—	+	—	Yes	
17	R H*	41	C	M	12	—	Advanced	—	+	—	Yes	
18	G M C	32	W	M	6	—	—	+	—	—	Yes	
19	I D B	31	W	M	7	—	Slight	—	+	—	Yes	
20	G C	36	W	M	9	—	Moderate	—	—	—	—	

\* Re-examined 15 months later



the moderately advanced cases, and it is a common finding in the markedly advanced cases. The fibrosis is a result of chemical irritation caused by silica in the dust and of mechanical irritation instigated by the asbestos fibers.

Another finding characteristic of this disease is the presence of peculiar golden colored, crustation-like bodies in the lungs of these patients. Stewart and Stewart and Haddow have suggested the name "asbestos bodies" for them. Gloyne described a technic whereby the central core of these bodies was found to be a minute asbestos fiber. He also pointed out that it is important to demonstrate tubercle bacilli before one can assume that tuberculosis is a complicating factor.

Clinically, the most striking symptom is

undoubtedly dyspnea. This is progressive, slow, and insidious in development and is due to inelasticity of the lungs and interference with blood supply. Cough and expectoration, especially the latter, may be nearly or quite absent except during bronchitic attacks. Anorexia, cyanosis, loss of weight, and emaciation are rather late manifestations, and are usually out of proportion to the physical signs, differing thereby from tuberculosis alone.

During the latter part of 1934 it was my privilege to examine the chests of 71 of 100 workers who had been dismissed from local asbestos plants. All had undergone physical examination before they were referred for roentgenologic study and were found to be physically disabled.

Stereoroentgenograms were made of each

CHART II —PULMONARY ASBESTOSIS MODERATELY ADVANCED CASES

	Name	Age	Color	Sex	Years' Exposure	Tuberculosis Present	Cardiac Hypertrophy Right-sided	Pericardial and Pleural Thickening	High Left Diaphragm	Trachea Displaced	Emphysematous Type of Chest	Comments
1	R A W *	26	W	M	5	—	—	—	—	—	Yes	No 2 L E W died one year after examination Tuberculosis
2	L E W	25	W	M	7	++	—	—	—	R	Yes	
3	J C S	36	W	M	8	—	Slight	—	—	—	—	
4	W L B *	30	W	M	15	—	Moderate	—	+	—	Yes	
5	C A S *	53	W	M	8	—	Slight	Yes	+	—	Yes	
6	R H S	57	W	M	5	—	—	Yes	—	—	Yes	
7	T R	40	C	M	5	—	—	—	+	—	Yes	
8	C D	33	W	M	9	—	Moderate	—	—	—	Yes	
9	J M	39	W	M	12	—	Moderate	Yes	+	—	—	
10	L M	41	W	F	7	—	Moderate	—	—	—	Yes	
11	C M	42	W	F	11	—	—	—	+	—	Yes	No 17 R G J, is in terminal stages of tuberculosis Death imminent
12	O B L	43	W	M	7	—	Slight	Yes	—	—	Yes	
13	R K *	39	W	M	10	—	—	—	—	—	—	
14	E C L	23	W	M	3	—	Slight	—	—	—	—	
15	S J	31	C	M	7	—	Moderate	—	—	—	Yes	
16	M I *	37	W	M	9	+	—	Yes	—	—	—	
17	R G J	38	W	M	12	++	Slight	Yes	+	L	—	
18	W H	24	W	M	4	—	Slight	—	+	—	—	
19	H H	20	W	M	1 1/2	—	Moderate	—	+	—	Yes	
20	U L J	38	W	M	10	—	—	—	+	—	Yes	
21	O G *	39	W	M	7	—	Moderate	—	—	—	Yes	
22	R G	27	C	M	7 1/2	—	—	—	—	—	—	
23	P F	38	W	F	11	—	Slight	—	—	—	—	
24	L F	53	W	F	12	—	Moderate	Yes	—	R	—	
25	W W F	40	W	M	10	—	Slight	—	—	—	—	
26	A W	40	C	M	1 1/2	—	Advanced	Yes	+	R	Yes	
27	S D	29	C	M	6	—	—	—	+	—	Yes	
28	J D	30	W	M	6	—	Moderate	—	+	—	Yes	
29	F C C *	39	W	M	8	+	—	Yes	+	—	—	
30	W L C	42	W	M	6	—	Advanced	—	—	—	Yes	
31	V O B	36	W	M	8	—	Slight	Yes	—	—	—	
32	A R B	54	W	M	12	—	Slight	—	—	—	Yes	
33	G L B	57	W	F	15	—	Moderate	—	+	—	Yes	
34	F A C	28	W	M	8	—	—	—	+	—	Yes	
35	C G *	31	W	M	8	—	—	—	+	—	Yes	

\* Re-examined 15 months later

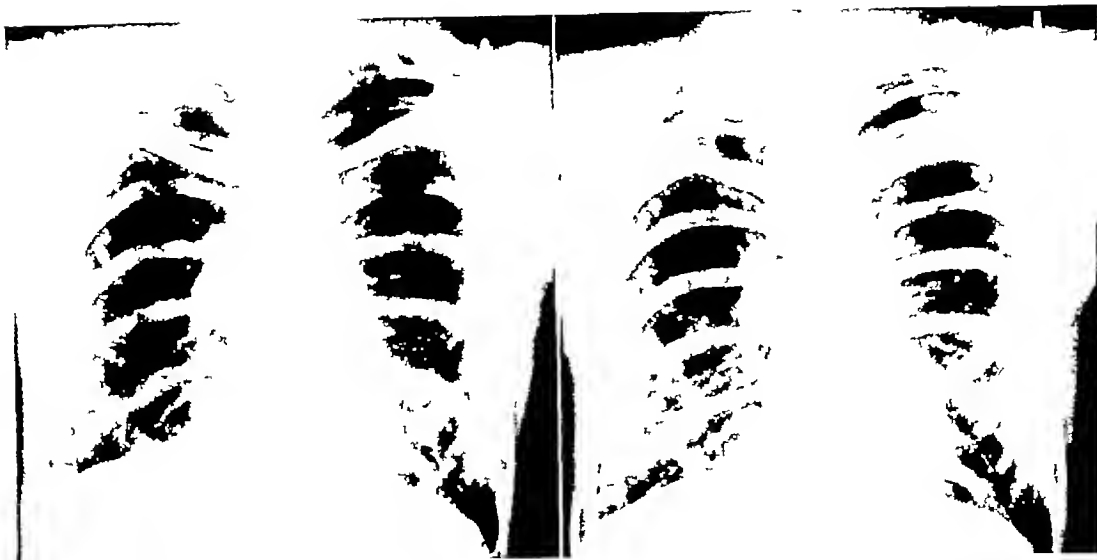


Fig 7

Fig 8

Fig 7 Case 3839 Examined on Jan 7 1935 white male aged 37 years Patient was exposed nine years Slightly advanced type of asbestosis Slight cough and some dyspnea but no time loss from work Note that in addition to the findings of asbestosis there is an active tuberculous lesion in the upper right lobe

Fig 8 Re examination made on Feb 15, 1936 Note improvement in lung fields No complaints Decided gain in weight Has worked steadily in a textile plant since discharge from asbestos mill in November 1934



Fig 9

Fig 10

Fig 9 Case 3738 Examined on Dec 1, 1934, white male aged 26 years Patient was exposed ten years Slight cough for one year Early type of asbestosis Note co-existing tuberculosis

Fig 10 Re examination made on Feb 10 1936 This patient has gained eight pounds in weight and has worked as a radio technician since his discharge from the asbestos mill in November 1934 Note fibrosing of tuberculous lesion and increased aeration of lung fields

ing them with a number of plates of other types of pneumoconiosis, it has been possible to make certain observations which seem to be peculiar to this group of asbes-

tosis cases as a whole These are tabulated under Table I

Furthermore, it was obvious that a classification could be effected Since the

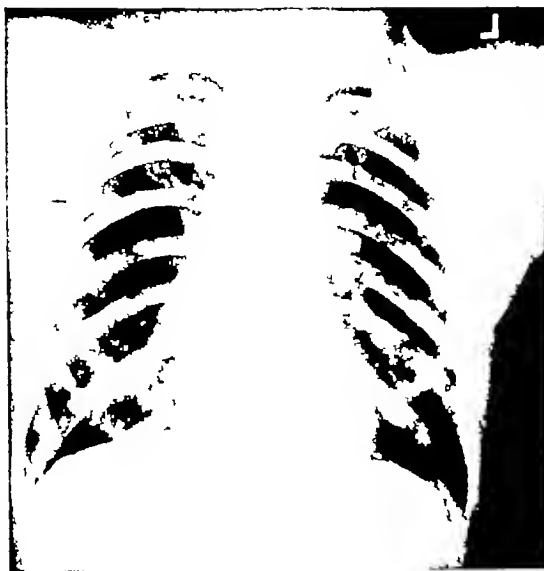


Fig 3



Fig 4

Fig 3 Case 3744 Examined on Dec 1 1934 white male, aged 24 years Patient was exposed two years Only complaint was a slight cough for few months Early type of asbestosis Note slight prominence of right auricle

Fig 4 Re-examination made on Feb 13, 1936 No complaints There is definite increased aeration of the lung fields

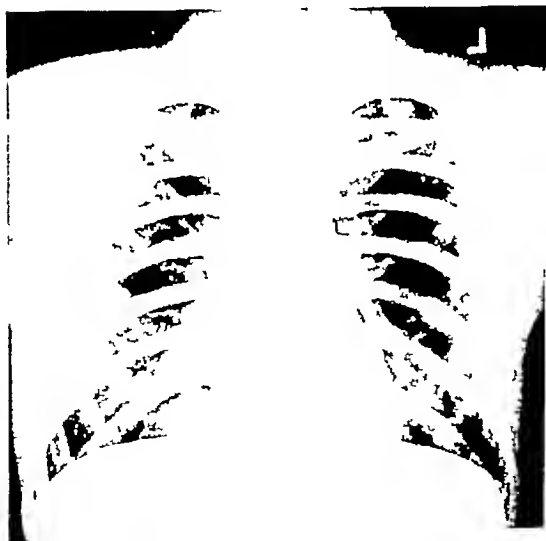


Fig 5

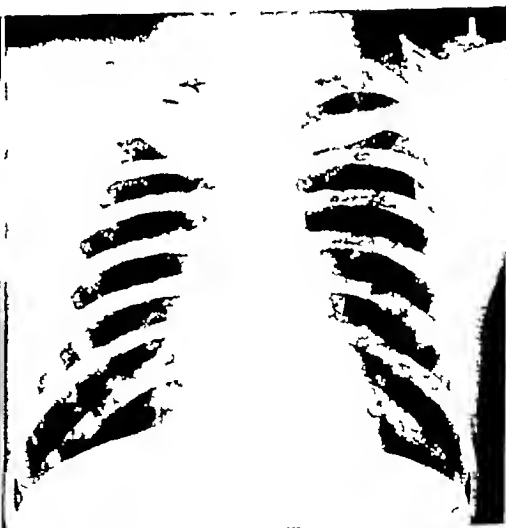


Fig 6

Fig 5 Case 3699 Examined on Nov 22 1934 white male aged 31 years Patient was exposed five years Early type of asbestosis with slight cough and dyspnea Note characteristic basal involvement

Fig 6 Re-examination made on Feb 13, 1936 No symptoms Note decided roentgenologic improvement

(11.3 per cent) in the entire series, the degree of infiltration was only slight to moderately advanced and one or both upper lobes were involved Only two cases appeared active

Since these examinations were made, five

patients have died Autopsy was performed on two, a detailed report of which will follow Of the remaining 66 patients, 21 have been re-examined recently

In studying the original and follow-up roentgenograms of the series and contrast-

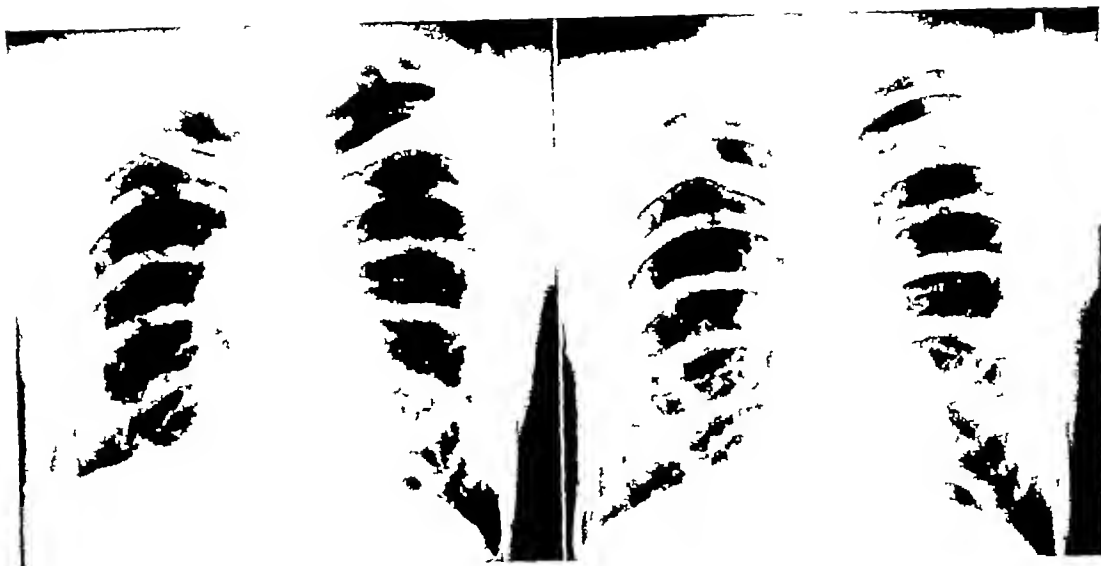


Fig 7

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Fig 8 Re examination made on Feb 15, 1936 Note improvement in lung fields No complaints Decided gain in weight Has worked steadily in a textile plant since discharge from asbestos mill in November 1934

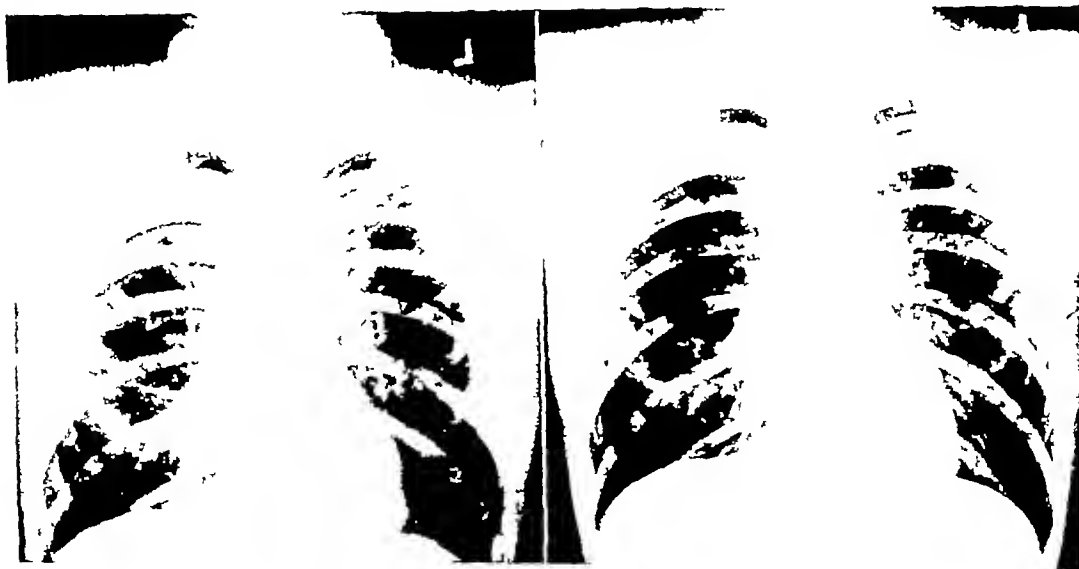


Fig 9

Fig 10

Fig 9 Case 3738 Examined on Dec 1, 1934, white male aged 26 years Patient was exposed ten years Slight cough for one year Early type of asbestosis Note co-existing tuberculosis

Fig 10 Re examination made on Feb 10 1936 This patient has gained eight pounds in weight and has worked as a radio technician since his discharge from the asbestos mill in November, 1934 Note fibrosis of tuberculous lesion and increased aeration of lung fields

ing them with a number of plates of other types of pneumoconiosis, it has been possible to make certain observations which seem to be peculiar to this group of asbes-

tosis cases as a whole These are tabulated under Table I

Furthermore, it was obvious that a classification could be effected Since the



Fig 11



Fig 12

Fig 11 Case 3771 Examined on Dec 5 1934 white male aged 37 years Patient was exposed eight years Moderately advanced type of asbestosis Note pericardial and pleural adhesions

Fig 12 Re-examination made on Feb 28 1936 No change in the appearance of the lung fields



Fig 13



Fig 14

Fig 13 Case 3755 Examined on Dec 3 1934, white male aged 26 years Patient was exposed two years He had previously worked on a farm Past medical history was entirely negative Moderately advanced type of asbestosis No subjective complaints Note miliary like deposits suggestive of a healed tuberculosis

Fig 14 Re examination made on Feb 22 1936 Patient now regularly employed in a textile plant No complaints Note slight but definite increased aeration

one constant feature of all these cases is unquestionably the diffuse fibrosis, this sign was taken as the "yard stick" in compiling such a classification After the groupings were arranged, the other roentgenologic findings were tabulated under each group

The following seems to be a satisfactory and working classification

- (1) Slightly advanced cases
- (2) Moderately advanced cases
- (3) Markedly advanced cases

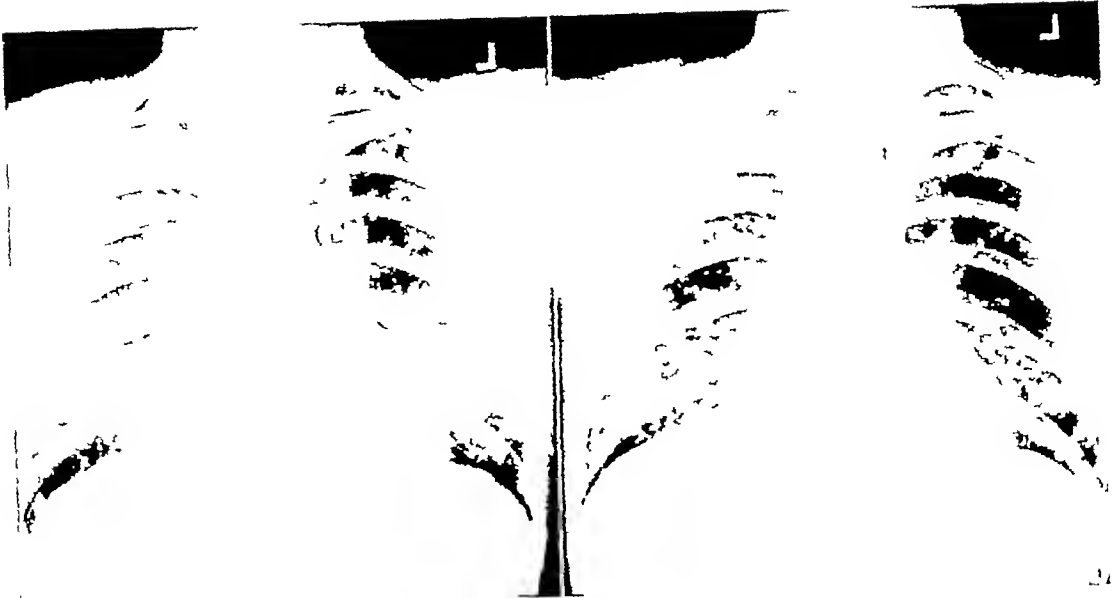


Fig 15

Fig 16

Fig 15 Case 3708 Examined on Nov 24 1934 white male aged 35 years Patient was exposed seven years Chief complaint was dyspnea Moderately advanced type of asbestosis

Fig 16 Re examination made on Feb 17, 1936 There is a slight increase in aeration of the lung-fields



Fig 17

Fig 18

Fig 17 Case 3743 Examined on Dec 1 1934 white male aged 38 years Patient was exposed eight years Cough and dyspnea were the chief complaints Markedly advanced type of asbestosis

Fig 18 Re-examination made on March 15 1935 Patient had an attack of lobar pneumonia in January 1935 Note changes in lung fields and in cardiac outline

1 *Slightly Advanced Cases* (Chart 1) — In this group are 16 cases. In all, there is a beginning interstitial fibrosis in both lung bases producing a filmy, hazy appearance. The roentgen film cannot be considered diagnostic; a history of exposure is neces-

sary to aid in arriving at a diagnosis. There are no cases of pericardial and pleural thickening, in none is the trachea displaced, rarely is there an emphysematous type of chest, and less than half showed right-sided cardiac hypertrophy. In this group there



Fig 19

Fig 19 Case 3751 Examined on Dec 3, 1934 white male aged 33 years Patient was exposed one and one half years He had cough for two months with moderate dyspnea Markedly advanced type of pulmonary asbestosis



Fig 20

Fig 20 Re-examination made on Feb 10, 1936 no improvement Note slight increase in cardiac base (This patient's father had worked in the same plant for five years prior to dismissal in September 1934 His lungs showed only an early or slightly advanced type)

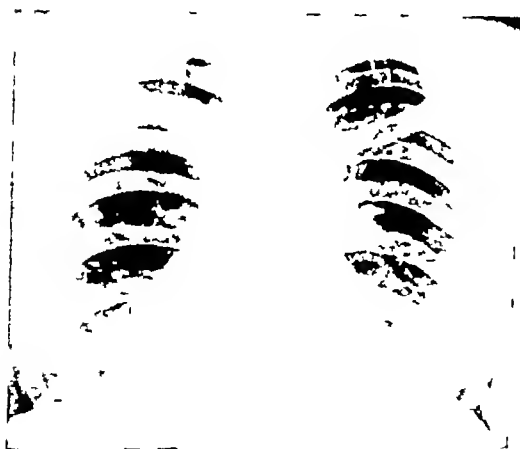


Fig 21 Case 3735 Examined on Nov 11, 1934, white male, aged 39 years Patient was exposed seven years Markedly advanced type of asbestosis Dyspnea was marked Note left diaphragm and characteristic basal involvement This film is typical of markedly advanced asbestosis as evidenced by basal involvement, fuzzy cardiac outline, high left diaphragm and the characteristic ground glass appearance of the lung fields

are two females and 14 males, all white The average age is 32.2 years and the average time of exposure is 5.4 years

## 2 Moderately Advanced Cases (Chart

2) —There are 35 patients in this group There is definite interstitial fibrosis radiating to the periphery and producing a ground-glass appearance to the lung-fields Bronchovascular markings are increased and pericardial and pleural thickening are noted Right-sided cardiac enlargement is more frequent and emphysematous types of chests are common The series contains five white females and 30 males five of whom are colored The average age is 37.1 years and the average time of exposure is 8 years

3 *Markedly Advanced Cases* (Chart 3) —There are 20 patients in this group In only one is there no roentgenologic evidence of right-sided cardiac hypertrophy and in only one other is evidence of an emphysematous type of chest lacking Nearly half have pericardial and pleural thickening and the majority show a high left diaphragm (Table I) The average age in this group is 37.1 years and the average time of exposure 8.7 years All are males, 16 white and four colored

In the entire series only six showed evidence of slight displacement of the trachea,



Fig 22

Fig 22 Case 3700 Examined on Nov 22 1934, white male, aged 36 years Patient was exposed ten years He had an unproductive cough with a negative sputum Note the shaggy heart Markedly advanced type of pulmonary asbestosis



Fig 23

Fig 23 Re-examination made on Feb 18, 1936 Chief complaint was dyspnea Note spread of fibrosis

and of these three had x-ray evidence of tuberculosis As would be expected, the degree of cardiac hypertrophy is largely dependent on the length of exposure Other findings do not seem to depend on this factor to the same extent Just what influence the degree of exposure, *i e*, the type and amount of dust inhaled, exerts on the roentgenologic picture is difficult to say, as it was not possible to determine this factor One would expect more serious and extensive pathologic changes in cases in which there has been a greater degree of exposure Undoubtedly there are other factors which play an important rôle in the amount of damage done to lung tissue the patient's constitutional make-up, his intelligence, previous disease of the lungs, and other causes may exert an influence in the rapidity with which the disease progresses I do not believe tuberculosis plays a significant part in the development or prognosis of asbestosis Roentgenologic evidence tends to uphold this statement Two of the patients with definite evidence of tuberculosis showed unquestionable improvement on re-examination 15 months subsequently Both are employed in other industries



Fig 24 See caption under Figures 25 and 26

The series of re-examined patients is too small, and perhaps insufficient time has elapsed, to draw definite conclusions on the progress of the disease from a roentgenologic standpoint When more patients have been re-examined over a longer period of time, such a report will appear However, the observations made on the 21 re-examined patients are worthy of note





Fig 25



Fig 26

Figs 24 25 and 26 Case 3792 Examined Dec 12 1934, white male aged 55 years Patient was exposed 25 years He had been totally disabled for the past two years Marked dyspnea troublesome cough emaciation and peculiar palor of the skin Markedly advanced type of asbestosis Note the shaggy heart and very little air space remaining This patient died one month after this examination Photographs of lungs and summary of pathologic findings after autopsy are found in the text

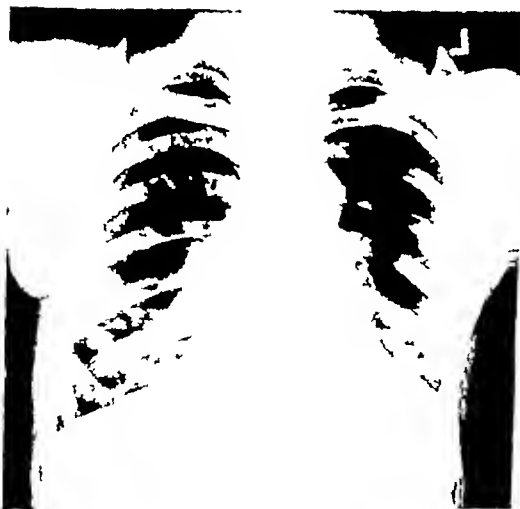


Fig 27 Case 3746 Examined on Dec 3 1934 negro male aged 30 years Patient was exposed seven years Chief complaint was cough of five years duration and recent continued hemoptysis There is some cardiac enlargement but no roentgenologic evidence of tuberculosis He died three months later and at autopsy tuberculosis was found (See report)

in the roentgen picture and in three there was an increase in the amount of fibrosis There was no improvement in the heart shadow in two, and in two it had enlarged Clinically four showed no improvement The fifth (See Figs 29 and 30) showed definite improvement

In the Moderately Advanced Group, seven were re-examined Three had gained a substantial amount of weight, two remained the same, and two had lost Three showed improvement in the lung picture and two a definite spread of the disease One showed an increase in the size of the heart and another showed definite improvement

In the Slightly Advanced Group, nine were re-examined Three had gained considerable weight and only one had lost Five showed improvement in the lung picture and only one any increased fibrosis In none was there any alteration in the size of the heart Three of these cases had roentgen evidence of tuberculosis Clinically these patients were much improved

Generally speaking, it would seem that improvement can be expected in the early cases when they are removed from asbestos

In the Markedly Advanced Group there were five re-examinations three gained some weight, one lost, and the other remained the same One showed no change

plants As the disease progresses, improvement is less likely, and when the condition becomes markedly advanced the patient usually becomes a permanent invalid and the prognosis must be considered entirely unfavorable Lanza states "It is by no means certain that asbestosis progresses as does silicosis after withdrawal from dust exposure, nor does infection seem to be as closely and intimately associated with asbestosis as with silicosis "

#### AUTOPSY FINDINGS IN ASBESTOSIS

Autopsy was performed on two patients in the Markedly Advanced Group One (S G ) died of an acute fulminating tuberculosis process, with continued hemaphys, three months after examination There was no roentgenologic evidence of this condition The other (P J V ) died one month after examination, of asbestosis Pathologic examinations of the lungs were made by Dr J B Bullitt, Professor of Pathology in the School of Medicine at the University of North Carolina

Case 1 (S G ) "*Gross* The lungs are somewhat distorted by being molded in the container The conditions in the two lungs are essentially the same The pleura over practically the whole surface is rough and apparently had been adherent to the parietes, in some areas it is as much as two millimeters thick The interlobular divisions are obliterated by adhesions except as below described The cut surfaces show nearly uniform character from base to apex, though the degree of damage is greater in the central and base portions Narrow grayish lines block the tissue into irregular small areas A few small gray spots, resembling tubercles, are scattered here and there from base to apex Near the central portion of each lung is an irregular shaped area of solidification, about two by three centimeters, which is apparently caseous pneumonia Similar areas of smaller size are found in the apical and in the basal portions In this area are small cavities about three or four millimeters in diameter Except in these areas, the tissue

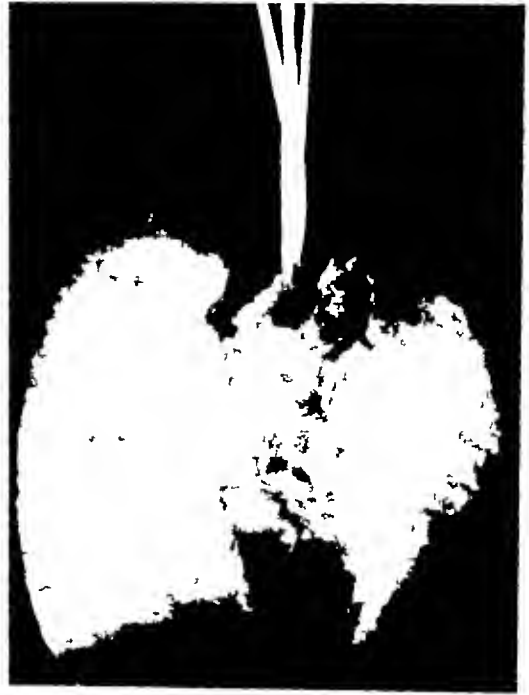


Fig 28 Case 3746 Roentgenogram of lungs following autopsy Lung mapping was attempted but was unsatisfactory Synopsis of autopsy findings reported in text

has an elastic feel, similar to but somewhat less than that of normal lung I find nothing to justify the massive hemorrhage that he is said to have had shortly before death The heart showed nothing of import The hilar lymph nodes are enlarged and mottled with caseous areas

"*Microscopical* In all parts of both lungs there is considerable fibrosis In great part, this consists of small irregular shaped nodules with lobular distribution, but also there is much fine fibrosis thickening the walls of alveoli that are still functional Most of this fibrosis looks like old healed scars, but much of it shows some infiltration with mononuclear cells, suggestive of a slowly progressive process In practically all these scars there is some pigment deposit—in some places a considerable amount, and also there are numbers of fine asbestos shreds I am confident that much of this fibrosis is due to the asbestos, though part of it might be healed tuberculosis In addition to this asbestos, the mi-



Fig 29

Fig 30

Fig 29 Case 3778 Examined on Nov 4 1934, negro male aged 40 years Patient was exposed 12 years He had had cough and dyspnea for two years Markedly advanced type of asbestosis with typical cardiac enlargement Measurements MR 5.5 ML 10.2 and Base 12.0

Fig 30 Re examination made on Feb 14 1936 Note diminished cardiac outline and increased aeration of the lung-fields Dyspnea now chief complaint, but not as marked as a year ago Measurements MR 4.5, ML 10.0, and Base 10.5

This is the only case in the markedly advanced group that has shown any improvement clinically or roentgenologically

roscope shows many very small typical tubercles in various parts of the lungs, moreover, the caseous areas mentioned above are characteristically tuberculous "

Case 2 (P J V) "*Gross* Both lungs are essentially alike The interlobar clefts are obliterated by dense adhesions The greater part of the pleural surfaces are roughened and appear to have been adherent to the parietes, though some areas are smooth and glistening and resemble the normal From apex to base, on the cut surfaces, the tissue is blocked off into small polygonal areas by narrow white lines In occasional places these lines broaden to as much as one to three millimeters, also at several places, just beneath the pleura, the pulmonary tissue is solidified into about five or six millimeters in thickness and twenty to thirty millimeters in breadth Except for the fibrosis above described, the pulmonary tissue appears essentially normal to the naked eye, but when pinched between the fingers it has a distinctly in-

creased density, especially in the lower lobes

"The hilar lymph nodes are much enlarged and their cut surfaces are slightly mottled with gray

"The heart is distinctly larger than the average normal The right ventricle is dilated, probably sufficiently to prevent perfect competence of the valves The muscle is pale and slightly streaked It is apparently not quite as firm in texture as normal The aorta and the heart valves show a moderate amount of atheroma

"*Microscopical* The microscope demonstrates an amount of fibrosis greatly in excess of what the naked eye would lead one to expect This is more marked in the lower lobes but is present in all parts of both lungs It consists of nodules and bands of connective tissue which have clearly resulted in the obliteration of much pulmonary tissue Much of it consists of old, hard scars with no present inflammation, but in much of it the process seems

progressive, as indicated by a low grade exudate (mononuclear cells) The rubbery plaques on the pleural surfaces are partly made up of thickened pleura, but mostly of actual lung tissue obliterated by fibrous tissue A good deal of pigment is present in most areas In all areas there are numerous spicules of asbestos Some of the scars in this lung might well pass for healed tubercles, but I find no present tubercles, and careful search fails to demonstrate any acid-fast bacilli in any area The lymph nodes at the hilum show hyperplasia, some little fibrosis, a moderate amount of pigment, and a few spicules (very small) of asbestos, but no evidence of tuberculosis

"Except for moderate atheroma, the aorta and heart show nothing of importance under the microscope"

#### ASBESTOSIS AND SILICOSIS

The roentgenographic picture of silicosis does not resemble asbestosis In the former, the upper third of the lungs is involved and the fibrosis is parenchymal and not interstitial The lung-fields show characteristic nodulation, and, in advanced cases a coalescence producing dense opaque areas in contrast with the typical, hazy, ground-glass appearance of the asbestosis lung-fields Silicosis is definitely a progressive disease, even when the patient has been removed from dust exposure This is not the case in asbestosis, certainly in the slightly and moderately advanced groups In asbestosis, there is a definite tendency to pleural and pericardial involvement which is strikingly absent in silicosis

#### MEDICO-LEGAL STATUS OF ASBESTOSIS IN NORTH CAROLINA

Just a word about the status of asbestosis in North Carolina from a medico-legal standpoint In the case of *McNeely vs Asbestos Co*, 206 N. C., page 568, the State Supreme Court held the plaintiff suffered an "injury by accident" The Court said "He alleged in his complaint and offered evidence tending to show that

his injury was produced and proximately caused by negligence of the defendant in that it maintains no dusting or suction system such as is approved and in general use in other asbestos plants Consequently his allegation and proof both established the fact that his injury was caused by the negligence of the employer and hence was not the usual incident or result of the particular employment in which the workman is engaged That is to say, the injury was not produced by the inherent nature of the work itself and classifiable as an occupational disease, but was produced by the active negligence of the employer and his failure to exercise reasonable care" The Court held in effect that the injury itself was an accident in that it was an unlooked for and untoward event which was not expected or designed by the plaintiff, and therefore was compensable under the Compensation Act As a consequence of this decision, the State Legislature of 1935 amended the Compensation Act to include twenty-five occupational diseases, including asbestosis

#### CONCLUSIONS

- 1 Asbestosis is a definite disease entity
- 2 Inhalation of air laden with asbestos dust and fibers produces characteristic changes in the lung
- 3 The time required for the development of the disease is variable The earliest patient in my series had worked in an asbestos mill only 16 months
- 4 The disease *asbestosis* differs from the disease *silicosis*, clinically, pathologically, and roentgenologically
- 5 While the roentgenogram is the most reliable diagnostic aid, the interpretation and correlation with clinical signs and symptoms is often difficult Without the history of exposure a certain number of slightly advanced cases will not be recognized
- 6 A fair percentage of the slightly advanced and the moderately advanced cases do tend to improve and the attendant dis-

bilities to become lessened when removed from asbestos dust

7 Asbestosis does not predispose to tuberculosis

8 From my observations asbestosis is not primarily a progressive disease

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RADIOGRAPHIC FINDINGS IN PULMONARY ASBESTOSIS

- 1 Emphysematous Type of Chest
- 2 Flaring of Lower Ribs

- 3 Trachea not Displaced
  - 4 Diffuse Fine to Coarse Fibrosis Reaching the Periphery Interstitial in Character Differentiating it from the Roentgenologic Appearance of Silicosis
  - 5 Hazy Ground glass Appearance of Lung fields
  - 6 Increased Density of All Pleural Markings
  - 7 Shaggy Appearance of the Cardiac Outline
  - 8 Tendency Toward Right sided Cardiac Enlargement
  - 9 Disproportionate Rise of Left Diaphragm
  - 10 Degree of Cardiac Involvement is not Consistent with that of Pulmonary Involvement
-

# THE INFLUENCE OF WAVE LENGTH ON DEPTH DOSE AS MEASURED BY PHYSICAL AND BIOLOGICAL MEANS<sup>1</sup>

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THE problem before us is to bring forth the evidence dealing with the question of the relative biological effectiveness of different wave length radiations

For a good many years, radiations varying in wave length from a few Ångströms (x-rays) to a few hundredths of an Ångström (gamma rays) have been employed in cancer therapy, yet no clear-cut impressions have been reached as to the relative efficiency of these radiations in bringing about favorable clinical reactions. It might be concluded from this fact that no significant wave length effect could exist or it would have been discovered long before this. However, because gamma-ray intensities are generally lower than x-ray intensities and because the methods of administering the two radiations are quite different, the comparisons have not been on the same basis and accordingly the results have not been strongly significant. Moreover, in clinical observation, it is difficult to obtain a satisfactory quantitative measure of the various biological changes induced, thus making exact comparisons impracticable.

With the advent of "supervoltage" x-rays and the prospects of having artificially produced gamma rays in large quantities obtainable under conditions comparable to x-rays, it is desirable to know whether any real advantage, aside from increased depth dose, is to be obtained by using the shorter wave length radiations in the production of radiobiological changes.

In view of the fact that conclusions on this question have not been reached in the clinic, and that, on the basis of this, the very existence of a wave length effect has been questioned, it is natural that experiments should have been undertaken in the

laboratory and that the most favorable test materials should have been employed for the investigation of the wave length problem. Should it be demonstrated definitely in any set of organisms that quality of radiation (wave length) as well as quantity (dose) is important in producing irradiation changes, it will then be time to investigate precisely the clinical implications, and the necessary effort involved will be justified.

We have compared the action of different wave length radiations on *Drosophila* eggs and a certain type of ionization chamber, and found that these objects respond in essentially the same way to the different radiations. That is, when we find by ionization measurements (using a certain ionization chamber) that the intensities of the two qualities of radiation are the same, equal exposures produce approximately equal killing effects on the eggs. On the basis of this alone we would conclude, as Packard has concluded (1), that quality of radiation is unimportant and only quantity, or dose, is to be taken into account when producing biological changes with radiation. Experiments have been carried out with other test objects, however, and these have caused us to reserve decision on the question. Furthermore, it seems risky to base conclusions on ionization measurements (in roentgens) of different qualities of radiation, for it has been shown by a number of investigators (2, 4, 6, 8) that such measurements are dependable only within certain wave length ranges (lower voltage x-rays).

In 1931, we (Failla and Henshaw) irradiated *Drosophila* eggs and the seedlings of *Triticum* (wheat), using 200 kv x-rays in one case and gamma rays in another and found approximately the same relative effects produced by the two radiations. Despite the fact that animal material was used in one case while plant material was

<sup>1</sup> Presented before the Radiological Society of North America at the Twenty-first Annual Meeting at Detroit Dec 2-6, 1935.

used in the other, and the fact that the amount of killing was the effect measured in one organism while retardation in growth was the effect measured in the other, the same results, in general, were observed. Accordingly, since we found no significant difference and since negative results in this case are trustworthy, our attention was turned from the direct study of the effectiveness of different wave length radiations to a different method of investigating the problem.

It is well known that a beam of  $\lambda$ -rays becomes softer, that is, increases in wave length, as it passes through a scattering and absorbing medium. Thus, by placing organisms at different levels in a medium, such as paraffin, they are subjected to different wave length radiations. By comparing, then, the effects observed at the various depths, some impression may be gained of the significance of wave length within the range generated by the scattering medium. Following such a procedure, we undertook to determine whether the same relative depth dose was observed with different test materials at different levels in a paraffin phantom when different wave length radiations were used as the incident beam. Stated more specifically, we attempted to determine whether depth dose curves for 200 kv  $\lambda$ -rays and gamma rays are the same according to observations made on different biological objects. Preliminary results presented previously for both 165 kv x-rays and 650 kv  $\gamma$ -rays indicate that depth dose curves are not the same for different test objects. The present work is an expansion of this investigation to include a greater range of wave lengths and certain other test objects.

While determinations have been made with a number of test objects, experiments will be described for only one ionization chamber (Chamber A) and two types of biological material—seedlings of *Lactuca sativa* L. (lettuce) and *Triticum aestivum* L. (wheat). Results obtained with *Lactuca* and *Triticum* were selected because they show more interesting responses to the different radiations and because our investiga-

tions have been carried further with them. Since extensive experiments have been carried out by Failla and his collaborators (3) to determine the influence of wave length on ionization measurements made at different depths in a scattering medium with ionization chambers, it was necessary for us to use only one of these chambers to relate our findings with biological materials to theirs obtained by physical means.

#### RADIATION AND APPARATUS

The gamma rays employed were obtained from a 4-gram radium element pack used generally for clinical work in this institution. A detailed description of this has been given elsewhere (1). At present, it is necessary to mention only that the radium element is contained in a series of platinum capsules which are distributed over an area 7.5 cm in diameter in the interior of a heavy lead housing, and that the nearest the phantom could be placed to the radium was 6 cm (Fig. 1). In addition to the filter provided by the platinum capsules, a piece of bakelite 3 mm thick was placed just above the test material to stop secondary radiation.

The  $\lambda$ -rays were obtained from an ordinary heavy glass, tungsten target, water-cooled, 200 kv Coolidge type  $\lambda$ -ray tube. The conditions maintained during treatment are given below.

The phantom employed was made of paraffin since this substance has an atomic weight about the same as that of tissues and, therefore, has somewhat analogous scattering and absorbing properties. Large discs 30 cm in diameter and 3.15 cm thick were moulded. Eight of these were arranged one above the other making the phantom 25.2 cm deep. Small cavities were excavated into the surface of certain layers to accommodate the test materials irradiated. The cavities for *Lactuca* were 2 mm deep while those for *Triticum* were 4 millimeters. Thus, since there was no cavity at the surface, and since distances were measured from the middle of the organisms at the surface to the middle of the

organisms at the different layers, the depth distances differed slightly for the different materials used. These differences are

measuring the two types of radiation in a common unit. In the absence of a better means, the small ionization chamber

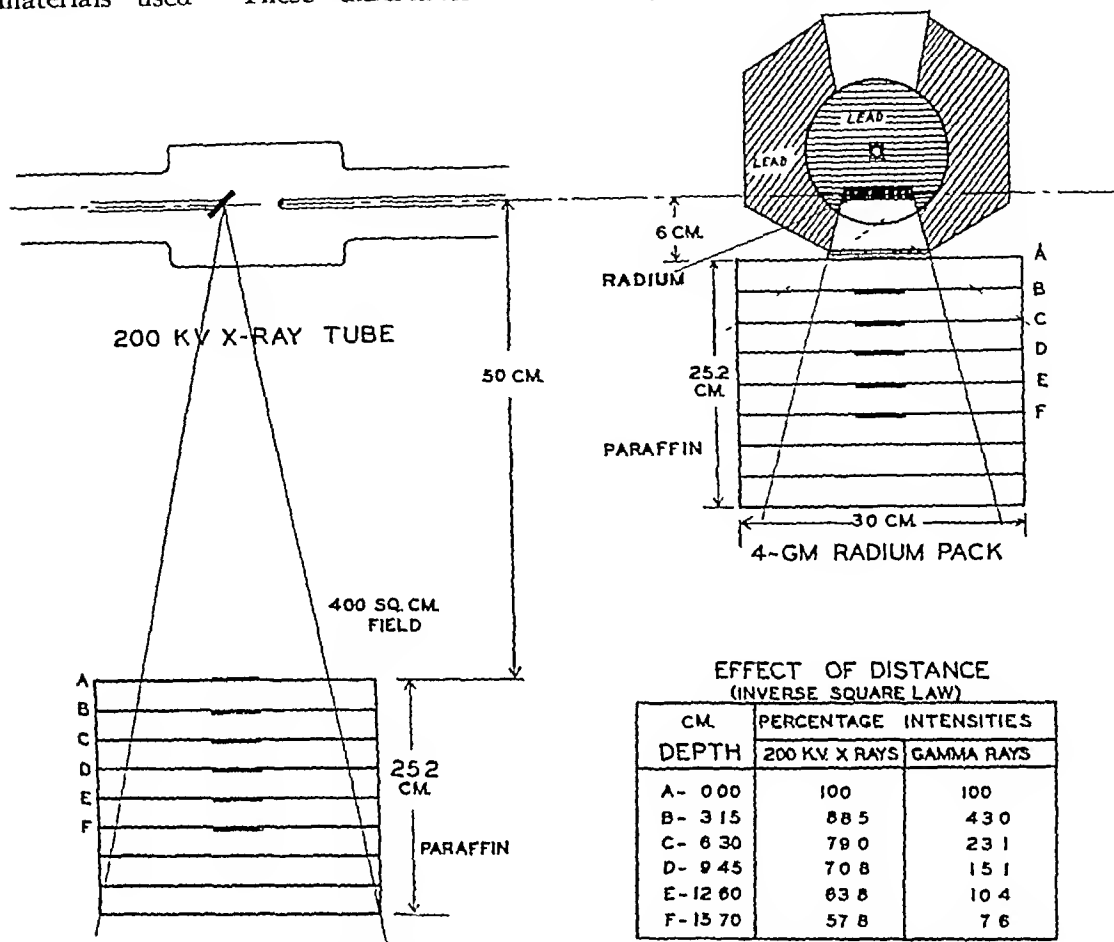


Fig 1 Diagram showing the relationship of the factors of distance, field etc., when 200 kv x-rays and gamma rays from a 4 gram radium element pack are used

taken into account in the graphs presented. Since the cavities differed somewhat for each material used, further mention will be made of them later.

#### PROCEDURE

In carrying out the experiments, a number of things had to be taken into consideration. First of all in order to eliminate time factor effects during treatment, it was necessary to adjust the intensity of the two radiations to be approximately the same. Since the gamma-ray intensity from the 4-gram pack remained fixed, it was necessary to adjust that of the x-ray beam accordingly. This necessitated some means of

(Chamber A), mentioned above, was used for this. Chamber A was first calibrated in a beam of x-rays to give readings in roentgens, it was then placed under the radium pack at a point where the nearest test materials were to be irradiated (6 cm) and the intensity determined. The reading obtained was 12.2 "roentgens" per minute. While the term *roentgen* is used here, it is not to be inferred that the gamma-ray intensity was measured in accordance with the definition of the roentgen, even though the chamber was calibrated to give readings in roentgens.

A more complete discussion of this subject will be presented by us in a separate communication to be published in RADIOLOGY.



Having found the intensity of the gamma-ray beam to be 12.2 r/min, the ionization chamber was placed under the x-ray machine at 50 cm distance from the center of the target, and the conditions adjusted to give 12.2 r/min. Since it was impossible to use a 6 cm distance, as in the case of the gamma-ray treatments, 50 cm was chosen because it has been used more or less as a standard distance for x-ray work (Fig. 1). The settings, conditions, etc., were as follows:

200 kv  
169 pv  
30 ma  
32 standard cell  
94 galvanometer  
3 23 mm Cu } filter  
2 4 mm celluloid }  
34 cm distance to filter  
14 X 14 cm diaphragm at 35 cm distance  
400 sq cm field at 50 cm distance  
(surface of paraffin)

A heavy filter was used in order to cut down the intensity without having to lower the voltages. The standard cell galvanometer arrangement was a device for keeping the intensity constant during treatment. It consisted of an ionization chamber which remained fixed in an otherwise unused portion of the x-ray beam and which was connected to a sensitive galvanometer. By adjusting the primary voltage to keep the galvanometer reading constant it was certain that the x-ray intensity remained practically constant.

Thus, as measured in air with a certain ionization chamber, the intensity of the x-rays and gamma rays were the same at the 50 and 6 cm distances, respectively. The gamma-ray intensity, of course, was fixed and needed no further attention during the course of the work. Special ionization readings were taken from time to time, however, to check the x-ray intensity and the galvanometer measurement of it, since there was a slight tendency to drift.

Having adjusted the intensities of the two radiations to be the same (by ionization), and having made provision for keeping them constant for a period of time, it was possible to proceed with the depth dose measurements.

Before describing the work, however,

TABLE I—MM LINEAR GROWTH OF 25 ROOTS

Minutes Exposure	0	45	90	135	180	225
Exp No	A Level—(Surface)					
1	892	580	508	451	387	310
2	930	768	619	483	416	357
3	904	633	531	361	312	227
4	979	650	545	403	338	246
5	972	717	508	278	229	210
6	1 087	882	716	534	386	332
7	1 006	649	566	556	431	328
8	845	678	604	481	367	328
9	923	643	506	416	339	235
10	724	443	412	322	279	242
11	933	677	452	264		212
12	929	517	425	334	247	188
13	921	540	279	176	146	116
14	953	658	513	238	205	177
15	1 033	634	503	215	172	162
16	849	678	535	318	255	230
17	952	752	427	280	182	179
Average	931	653	513	359	293	240
Percent age	100	70.1	55.1	38.6	31.5	25.8
	D Level—9.65 cm Depth					
1	892	599	549	525	425	420
2	930	817	790	760	648	538
3	904	800	634	590	513	449
4	979	696	655	599	581	564
5	972	825	750	736	554	543
6	1 087	1 010	867	764	673	640
7	1 006	806	695	614	599	548
8	845	732	676	627	621	576
9	923	717	656	526	520	499
10	724	504	448	374	368	366
11	933	781	688	668	572	500
12	929	568	505	559	509	425
13	921	657	618	539	407	322
14	953	734	722	717	643	479
15	1 033	856	804	719	554	521
16	849	774	746	718	577	502
17	952	864	828	663	449	434
Average	931	750	690	629	542	490
Percent age	100	80.6	74.1	67.6	58.2	52.6

mention should be made of two factors which differed appreciably for the x-ray and gamma-ray treatments—distance and size of field. As mentioned above, the gamma-ray intensity at 6 cm, the nearest point at which test material could be placed, was low, making it impracticable to use greater distances. Such a distance, however, obviously could not be used under the x-ray tube. Aside from the shape of diaphragm used, the distance differences alone were sufficient to cause the size of field and irradiated volume in the phantom to differ markedly. Figure 1 has been drawn (to scale) to show these differences more clearly.

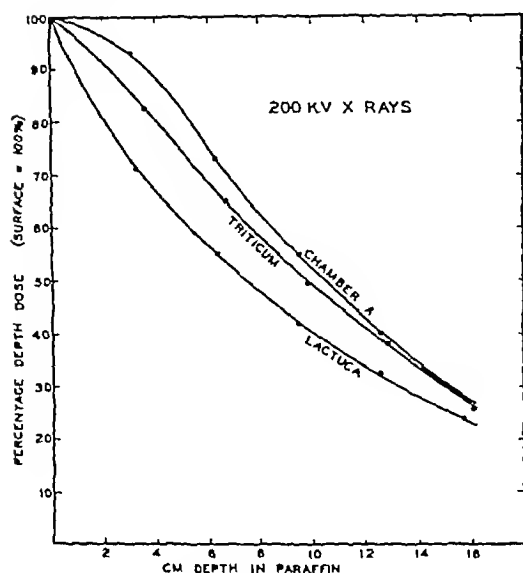


Fig 2

Fig 2 Depth dose curves for Chamber A, *Triticum* and *Lactuca* obtained with 200 kv x rays

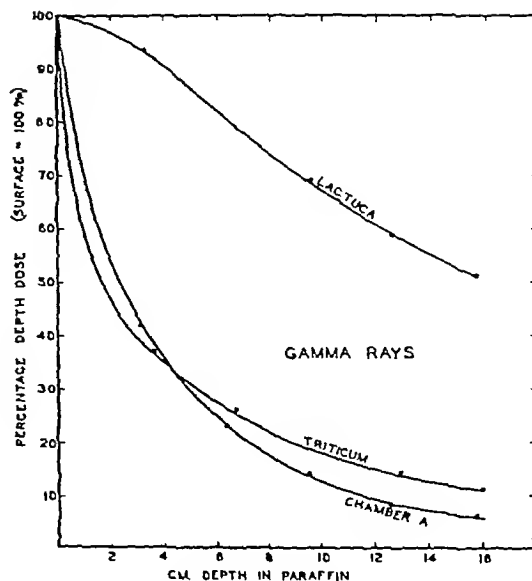


Fig 3

Fig 3 Depth dose curves for Chamber A, *Triticum* and *Lactuca*, obtained with gamma rays

While we should have preferred to have these factors the same for reasons of simplicity, they do not interfere with the determination of relative wave length effects on different materials. As will be seen, the shape and location of the depth dose curves will differ in the two cases, but what we are concerned to learn is whether the curves obtained with different test objects are the same for a given radiation. To determine this it is not necessary to have the distance and irradiated volume of medium the same in each case. It will be seen, nevertheless, that while the irradiated area at the surface in case of the radium pack is smaller than in case of the x-ray set-up, the irradiated volumes are not greatly different, so that the absorbing and scattering properties of the phantoms in each case are reasonably alike.

#### IONIZATION MEASUREMENT OF DEPTH INTENSITY

Ionization measurements carried out at various depths of the paraffin phantom were made with Chamber A, which was spherical and made of celluloid 1.4 mm thick and having an inside diameter of 1.52

centimeters. For the surface measurement, the chamber was arranged half submerged in the surface of the first layer of paraffin, while for the others it was placed between the layers at the various depths. In all cases, the paraffin was moulded around the surface of the chamber to avoid air spaces. When measurements were made under the radium pack, the surface of the phantom was placed at 6 cm distance from the radium and always in such a way that the ionization chamber was at the center of the beam. When x-ray measurements were made, the phantom was similarly arranged except that the surface was at 50 cm distance (Fig 1). Since the findings here have a bearing on several other investigations, they were carried out with all possible precision. The results obtained are shown in Figures 2 and 3.

#### BIOLOGICAL MEASUREMENTS OF DEPTH DOSE

Complete depth dose curves have been obtained with the seedlings of *Lactuca* and *Triticum* for both x-rays and gamma rays. In both organisms the effect observed was retardation in linear growth of the primary root. The procedure followed, and the

TABLE II—EXPOSURE VALUES AND RATIOS FOR CORRESPONDING EFFECTS PRODUCED AT DIFFERENT LEVELS IN THE PARAFFIN PHANTOM

Level	A	B	C	D	E	F
Minutes Exposure						
% growth						
77 5	25	34	46	65	90	123
75 0	32	44	58	79	103	144
72 5	39	54	70	96	126	165
70 0	46	64	84	109	144	187
67 5	53	76	97	125	162	208
65 0	61	86	110	141	180	228
62 5	68	98	123	156	198	
60 0	76	108	137	172	216	
Percentage Effect at Surface						
77 5	100	73 5	54 3	38 4	27 8	20 4
75 0	100	72 7	55 1	40 5	29 6	22 2
72 5	100	72 1	55 8	40 0	31 0	23 0
70 0	100	71 8	54 7	42 2	32 9	24 0
67 5	100	69 7	54 0	42 4	32 7	25 5
65 0	100	71 0	55 5	43 2	33 8	26 8
62 5	100	69 5	55 3	43 0	34 4	
60 0	100	70 4	55 5	43 9	35 2	
Av	100	71 3	55 1	41 9	32 2	23 9

variation in results obtained in each case were about the same so that details will be given for only one—*Lactuca*

Germination in this organism was induced by wetting the seeds and maintaining them in a moist chamber on moist filter paper at  $26^{\circ}\text{C} \pm 2.0$ . After 18 hours the primary root is just beginning to break through the seed coat, this is the stage at which treatment was administered. For treatment, the seedlings were arranged evenly on moist sectors of a circle of filter paper. Six such circles (five sectors each) were prepared and arranged as follows: Cavities 5 cm in diameter and 2 mm deep were made in the surface of the second, third, fourth, fifth, and sixth paraffin layers at the center. Filter paper circles containing seedlings were placed in each of the cavities and one was placed on top of the first layer. Treatment was then begun and one sample (sector of seedlings) was removed from each level at the end of each of the following exposures—45, 90, 135, 180, and 225 minutes. Experiments with x-rays and gamma rays were not performed simultaneously nor were they done on alternate days, but a few of one and then

a few of the other were done, depending on when the radium pack was available. Each sample of material was placed in a separate moist chamber and the seedlings spread evenly over the available area. At the end of treatment, all samples, together with controls, were put away in an incubator at  $26^{\circ}$  to await growth.

At the end of 96 hours after treatment, the linear growth of 25 primary roots was measured for each sample treated. A sample of data obtained is shown in Table I which gives the results for tests made at the surface and at the D level (9.65 cm as used for *Lactuca*) with x-rays.

Values were averaged in each case and expressed in percentage growth of the controls. The percentage values were then plotted as shown in Figure 4, presenting a family of dose-effect curves for the different levels in the phantom. Table II shows the minutes of exposure (taken from Figure 2) required at each level in the phantom to retard the growth to certain corresponding amounts. In the lower part of this table, these values are expressed in percentage with the effect at the surface taken as 100 per cent. The averaged values, together with similar ones obtained with *Triticum* seedlings, are shown for x-rays in Figure 2. Likewise, in Figure 3 the depth dose curves for *Lactuca* and *Triticum* are shown for gamma rays.

#### DISCUSSION OF RESULTS

It is evident from Figures 2 and 3 that the curves for different test objects present significant differences.

Referring first to the 200 kv x-ray results, it is seen that while the curves follow the same general course there is some separation between them. The curve for Chamber A is above those for *Triticum* and *Lactuca*, and the curve for *Triticum* is above that for *Lactuca*. This indicates that the ionization chamber detects relatively more radiation at the depths than do the biological test objects, and that *Triticum* detects more than *Lactuca*. While the differences

are not large, they are, nevertheless, appreciable. Furthermore, it is interesting to note that although the conditions (distance filter, field, and intensity) are somewhat different, the curves for Chamber A and *Triticum* bear the same general relation to each other as those described previously for 165 and 650 kv x-rays, thus bearing out the conclusion that biological and ionization measurements of radiation intensity are not necessarily the same.

Examining now the gamma-ray curves, marked differences are observed. Not only is the order of their position changed but also there is wide separation and crossing. Whereas the *Lactuca* curve fell beneath those for Chamber A and *Triticum* when 200 kv x-rays were used, it lies well above them when gamma rays are used. The curve for Chamber A follows a smooth course and is not greatly different from that based on the Inverse Square Law (see the Table, Fig 1). The *Triticum* curve drops away more rapidly at first, then crosses the ionization curve at 4 to 5 cm depth, and rises above it. From the experimental points plotted in Figure 3, some question might arise as to whether the crossing of the *Triticum* and Chamber A curves is exaggerated. To investigate this, points were obtained for shallower depths and the curves verified. These additional points have not been included because the exposure conditions differed slightly.

It appears, therefore, that as far as *Triticum* is concerned, the effective radiation drops off rapidly near the surface in the phantom, and then, due to some compensatory action, remains almost constant. The term "compensatory" is used because, by the Inverse Square Law alone, the intensity would drop away more rapidly than indicated by the *Triticum* curve.

Comparison of the curves of *Triticum* and Chamber A (gamma-ray data) indicates evidence of differential effects at different levels in a paraffin phantom, comparison of the *Lactuca* curve with those of *Triticum* and Chamber A demonstrates even greater differential effects. At 10 cm depth, for example, the radiation intensity

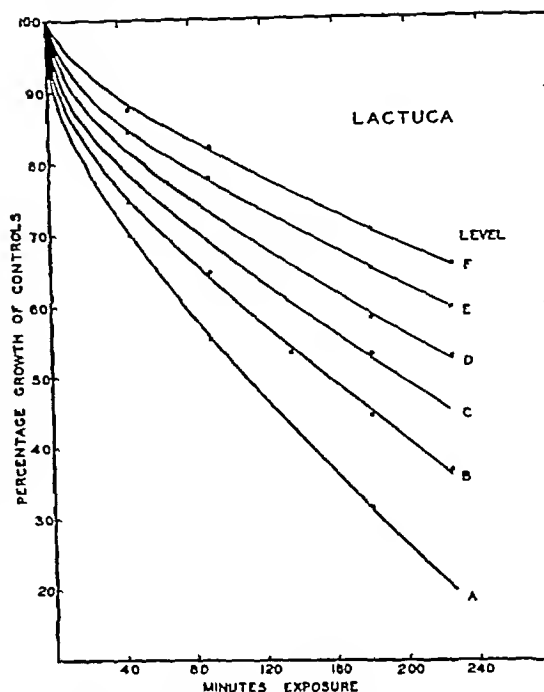


Fig 4 Dose-effect curves obtained at different levels in a paraffin phantom

as detected by *Lactuca* is several times that detected by *Triticum* and Chamber A, and correspondingly wide differences exist throughout the extent of the curves.

Hence, since the flux of radiation present at any level must be the same, irrespective of the test object used, the differences observed would seem to be due to the differential effectiveness of the different qualities of radiation present at the various levels. The magnitude of differential effect manifest, however, is so great and unexpected, in view of the fact that direct comparison of wide wave length differences revealed no significant differences, that we were led at once to question the experimental results. Accordingly, calculations have been checked carefully and a variety of experiments have been carried out to locate possible errors. Some variation was obtained when the experiments were performed in different ways, but none which compares to the magnitude of difference separating the *Lactuca* curve from the other two when gamma rays are used. However, since circumstances may yet arise which would make it necessary to interpret the results in another way, we wish

merely to present the findings here as an experimental observation suggesting a differential effect due to wave length

#### SUMMARY

Intensity measurements of x-rays and gamma rays have been made at various levels in a paraffin phantom using an ionization chamber and two types of biological test objects. Curves showing how intensity varies with depth in each case were found to be generally alike for x-rays and quite different in the case of gamma rays.

Such results indicate a differential response on the part of the test objects, and since, so far as we know, radiation at different levels in a scattering medium differs only with respect to wave length, these results suggest a differential effect produced by different wave length radiations.

The writers wish to express their indebtedness to Dr G Failla for helping to plan these investigations and for his interest and co-operation throughout the course of the work. Thanks are also due to members of the Physics Department for making the ionization measurements.

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## ACUTE GASTRIC DILATATION OF STOMACH DURING ATTACK OF MIGRAINE

By J KAUFMAN, M D , and I LEVINE, M D , *Brooklyn, N Y*

**M**IGRAINE has been defined as an affection characterized by paroxysmal attacks in which a distinctive type of headache, usually unilateral, is the most constant feature, commonly accompanied by nausea and vomiting. This condition is more common in females and occurs preponderatingly in neurotic families. The immediate exciting cause of an attack in individuals who are predisposed

cation, refraction anomalies, nasal disease, etc. Goldzieher (2), in discussing headache of the migraine type, states that it may be on a definite endocrine basis, and that recent investigations have added new indirect evidence that headaches of the migraine type are related to increased intracranial pressure. Such patients show the appearance of the anterior pituitary hormone in the urine prior to the onset of



Fig 1

Fig 1 Showing the marked gastric dilatation and atony during the attack of migraine



Fig 2

Fig 2 Showing the same stomach completely recovered after the attack had subsided

to it is any undue fatigue or excitement of the nervous system.

These patients very often show symptoms suggestive either of an irritation or paralysis of various components of the sympathetic system. The close relationship of the stomach to the autonomic nervous system accounts for the marked frequency of gastric symptoms in cases of migraine.

The etiology is considered by some authorities to be due to local angio-spasms causing focal symptoms in the brain, by others to be due to recurring auto-intoxi-

the headache. Hyperfunction of the anterior lobe and spilling of the hormone in the urine are constant features of increased intracranial pressure, which is probably due to water accumulation in the brain tissue.

Hunt (1) investigated 60 cases of migraine, 40 of which had symptoms referable to the gall bladder. In 17 cases, oral cholecystography showed evidence of gall-bladder or hepatic disorders. He found that gall-bladder disorders were more frequently encountered in patients with mi-

graine than in normal patients, and consequently stressed the importance of inquiring about migraine in patients with gall-bladder disease

Vaughan (4) reported 33 cases of migraine, 36 per cent of which were due to allergenic foods. More than one-half of these patients complained of vomiting. Mackintosh and Anderson (5), in discussing migraine, state that nausea and loss of appetite occur in the large majority of cases and that as a rule any food taken is not digested, all digestive and absorptive processes in the alimentary canal appearing to be in abeyance in severe attacks.

We present the following case because of the graphic manner in which it demonstrates the marked changes that the stomach can undergo through nervous stimuli, and because it stresses the importance of a thorough clinical history before any conclusion can be drawn from the x-ray examination.

F. H., female, aged 35 years, married, was referred for radiographic examination because of repeated attacks of migraine associated with nausea and vomiting. The family history is important, in that the patient has a sister who suffers from aerophagia. The patient's history is irrelevant, other than the fact that she has always been a "nervous" individual. The present complaint dates back three years, at which time she began to complain of left-sided headaches, which increased in severity and were associated with nausea and vomiting. Correction of a refractive error did not improve the condition.

Radiographic examination of the fasting stomach (patient had no food or drink for 15 hours prior to the examination) revealed a tremendously dilated stomach. Under fluoroscopic examination it was obvious that, in spite of the abstinence from food, there was considerable reten-

tion of both fluid and food in the stomach. The stomach was atonic. The barium filtered through the gastric contents and settled to the bottom of the stomach. Throughout the fluoroscopic and plate examinations no evidence of peristalsis was noted. Very little barium passed through the duodenum. The patient vomited twice before the six-hour plate was taken, but nevertheless there was a retention of about 60 per cent of the meal on the six-hour plate. At the time of this examination the patient was having an attack of migraine, and another examination was advised when the attack subsided. The second radiographic examination, taken 24 hours after the attack had subsided, revealed a fish-hook type of stomach, the lower border being at the level of the iliac crests. Peristalsis was active. No defects of form or function were observed either in the stomach or duodenal bulb. In six hours the meal showed normal motility.

#### CONCLUSION

A case of migraine is presented, showing acute dilatation of the stomach during an acute attack with recovery subsequent to the subsidence of the symptoms. This type of case is being investigated further to determine the consistency of the radiographic findings, and also in an attempt to judge the efficacy of the various medications through their action on the stomach as judged by the radiographic examination.

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# SOME LAWSUITS I HAVE MET AND SOME OF THE LESSONS TO BE LEARNED FROM THEM<sup>1</sup>

(Tenth Installment)

By I S TROSTLER, M D, F A C R, F A C P, Chicago

A GOITER CASE (*res ipsa loquitur* DOES NOT  
APPLY IN WISCONSIN<sup>2</sup>)

A CASE of roentgen dermatitis referred for opinion and advice, which was rather roughly handled by the writer (the case, not the patient), ended far differently from the way we anticipated and foretold

An attorney for an insurance company wrote as follows "A case prosecuted by a Mrs D K, of F—, Wis, against Dr G T B, of the same city, is pending in the Circuit Court and will be tried within a short time in that city The plaintiff is represented by Messrs R— and O'B— and the defendant by Mr J F K—, of the law firm of B H K & D, of Oshkosh, in our behalf

"From a report submitted to us by Dr B—, he advises us that he was treating Mrs K—, a widow, approximately forty years of age, for goiter He was using a Victor Universal machine and says that his first treatment was administered April 21st last His factors were 5-inch spark gap, 6 ma of current, for 6 minutes through 2 mm aluminum, at 13 inches anode-skin distance The treatment was renewed on April 29th, May 5th, and May 12th It appears that during June and July, the Doctor was on his vacation in Europe and on his return on July 21st and a week later, to-wit, July 28th, two more treatments were given the patient, the factors being the same with the exception of filtration, which was reduced to 1 mm of aluminum On or about the 6th or 8th of August, evidences of a burn became apparent

"Commencing May 2nd and continuing on the 7th and 14th of May, July 24th, 29th, and 30th, the Doctor gave what he called a tonic treatment, quartz light or ultra-violet ray The time for this varied from one to six minutes This was not given at that time as treatment for any burn, because no burn had at that time asserted itself

"The ultra-violet ray treatment was continued on the following dates August 1st, 3rd, 8th, 10th, 12th, 14th, 17th, 19th, 22nd, 24th, 26th, 28th, September 1st, 3rd, 5th, 7th, 9th, 11th, 14th, 16th, 18th, 21st, 23rd, 25th, and 28th, and the time of each treatment varied from one to six minutes, according to the judgment of the Doctor, based on the condition of the patient and the burn from time to time The idea of the ultra-violet ray treatment was to cure the burn

"Assuming, a spark gap of 5 inches, milliamperage of 5, and a 13-inch distance which the Doctor reports, through 1 mm of aluminum, we figure, according to the Witherbee and Remer formulæ, that 4 minutes and 22 seconds would be a skin unit, or 31 minutes and 2 seconds an erythema So far as the factors are concerned, a burn should not have occurred

"It seems that the filtration was shortened at the suggestion of some London Doctor whom Dr B— met, while sojourning in Europe As soon as the filtration was reduced to 1 mm of aluminum, the burn came into evidence

"It is our understanding that the point of the burn is under the right ear We understand the anode arm of the tube was directly above the right ear

"We attempted to account for the burning in the following manner, which we sug-

<sup>1</sup> The Editor desires to state that much of the matter herein has to be printed in form as received without normal punctuation or phrasing

<sup>2</sup> Kuchneman vs Boyd 214 N W R 326 (1927)



gested to Mr K——, and he desires confirmation of our theory. We copy from our letter to Mr K—— 'We understand the severest burn is about the ear. We offer the following reasons for that burn. Assuming the positive pole of the x-ray tube to be immediately above the right shoulder of the patient, we take it that x-rays are discharged through the arm of the positive pole. The discharge of x-rays through the positive pole end of the tube cannot and was not, at the time the services were rendered plaintiff, controllable. That x-rays were discharged through the positive arm of the tube was evidenced by the fact that much x-ray equipment and especially the tubes are now being furnished with the tube fully enclosed in a lead cylinder. For your information, a photograph of such enclosure torn from the "American Journal of Roentgenology" is herewith enclosed and your attention is called to the enclosure for the tube.

"We are also enclosing herewith a sketch of a Coolidge tube which we have marked with the negative and positive poles. The positive pole supports what we have marked as D, which is the anode or target, and the arm, of course, would be called the target arm anode arm. The potential on the negative pole is controlled through the autotransformer. A suitable potential is first applied to the cathode which has the effect of releasing the electrons. In order to actuate this tube, it is necessary to have a suitable high potential current. In the Coolidge tube the electrons are liberated from the atoms of the tungsten filament by means of heat. In the Coolidge tube they arise at the filament which we have marked as C, which is more or less encased in a focussing cylinder, which we have marked as B. When the electrons are available, a suitable potential is applied to the tube terminal, and causes the electrons to leave the cathode and travel to the anode at a high velocity. This stream of electrons is known as the cathode ray. At the target, upon which the cathode stream is focussed by virtue of the concave cathode which we have marked A, the electrons are suddenly

arrested, giving rise to electro-magnetic pulses which travel in all directions from the target. These electro-magnetic pulsations or waves are the x-rays.

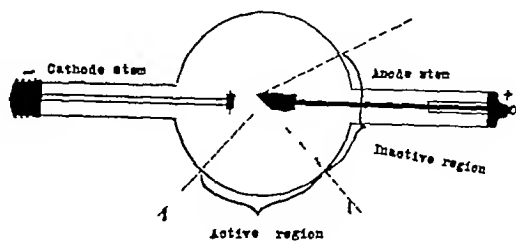


Fig 1

"Attention is called to the fact that the electro-magnetic pulses, which are other words for x-rays, travel in all directions from the target. Immediately beneath the cathode and anode of the tube is a space called the active hemisphere and beneath this and to the equipment is attached a cone for the purpose of directing the rays to the spot to be irradiated. These cones are usually made of lead and, of course, lead is impervious to the x-ray. The rays will not pass through the cone, that is, the sides. However, between the points that we have drawn in red on enclosed diagram, there are x-rays and, since they cannot be controlled, there is a probability that these rays passing down on to a part of the body not under irradiation and cause a burn.

"It is well to keep in mind that it is the long wave x-ray that does the harm. The long wave length is due to a small voltage. In this particular case they were using about 5-inch gap, or approximately 50,000 volts, which is very small in x-ray therapy.

"If some doctor, acquainted with radiology, would testify that it is possible to have a discharge of the x-ray back of the target or through the positive pole or arm of the tube, and that there is no way or at least there was no way of controlling these rays at the time the services were rendered plaintiff, we do not believe that liability should be imposed upon us, as a result of the passage of the rays through that arm of the tube. Undoubtedly this could happen, otherwise there was no necessity for en-

casing the full tube in a cylinder as was evidently done by the Peerless Electro-medical Corporation, as evidenced by their advertisement which is enclosed herewith'

"For your information, we are enclosing a rough sketch (Fig 1) of an x-ray tube. We have outlined what we term the anode region, contending that within the red lines there is always a constant x-ray discharge. We understand this is correct. Assuming x-ray discharge through the anode arm of the tube, what could a roentgenologist do to avoid burning a patient on any region of the body that may be exposed to the rays beneath the anode arm? We assume this will be readily answered by saying that lead foil should be used.

"Mr K——, in a letter to us, makes the following inquiries: 'I have an appointment with Dr B—— for this afternoon. I have asked him to come to Oshkosh. I want to present to him and Mr C——, of the Oshkosh Clinic, the theory advanced by you. If this theory can be supported and we can locate the initial point of burning as back of the ear or some distance removed from the point irradiated, the defense suggested seems to be complete. Could we not get some help from the manufacturer? When did the improved tube first make its appearance? When were the escaping x-rays through the arm first discovered, or, more to the point, when was the preventative first put into use? By whom could that be established?'

"We are taking the liberty of submitting this case to you and would be very pleased to have your suggestions.

"We are especially interested in knowing whether or not you are licensed to practise medicine in the State of Wisconsin. A license is now necessary in order to qualify as an expert witness in that State, as the statutes now provide that all experts shall be licensed to practise within the borders of that State.

'In the event that you agree with our theory and are licensed to practise in Wisconsin, we would be very pleased if you would advise us of that fact so that we may communicate with Dr B—— and Mr

K—— to arrange to see you and arrange for your presence at the trial."

The familiarity of the attorney who wrote the foregoing letter, with roentgen phraseology, the Coolidge tube, etc., is one of the principal reasons why the writer has for years advocated that we carry our malpractice insurance with companies that know how to fight. How many attorneys in this country could write such a letter? I venture to say that not ten could do so.

I replied as follows: "*In re* K—— *vs* B——, relative to the above captioned case, will say that, while the technic described (5 in spark gap, 5 ma 6 min, 2 mm Al filter at 13 inches F D) might not produce a burn under ordinary conditions, when this same dosage would be applied to a patient having a goiter, four successive times at 7-day intervals, in my opinion it would be considered by almost any experienced roentgenologist as overdosage and not proper treatment for goiter. When the same technic (except one millimeter of aluminum was used instead of two, for filter) for two later applications at weekly intervals, it is my opinion that whoever did so apply the second series displayed further ignorance of what is proper treatment and great lack of knowledge of approved methods in the treatment of the disease under discussion. It is generally known that goiter patients do not tolerate full dosage of x-rays.

"The administration of the ultra-violet radiation along with, and at the same time as, the x-rays is in agreement with the methods of but one writer and he is discredited. It is a method advocated by the representatives of the manufacturers of lamps and apparatus which generate those ultra-violet rays and is by these commercially tainted men claimed to produce a greater tolerance to large doses of x-rays. Careful investigation and proven experimentation by some of the best and most careful and competent radiologists in this country have proven that this claim and these claims are absolutely without foundation in fact. Recent publications have reproven this.

"I fail to understand your methods of computation, when you say in the first new paragraph on page 2 of your letter, 'assuming a spark gap of 5 inches, ma of 5 and a 13-inch distance, which the Doctor reports,' etc, to the end of the paragraph According to Shearer's formula on page 137 of MacKee (2nd Ed), the equation according to the figures you give would be

$$\frac{5 \text{ (ma)} \times 5 \text{ (S G)} \times 6 \text{ (min)}}{13 \times 13 \text{ (F S D)}} \text{ equals } \frac{150}{169} \text{ or}$$

practically  $\frac{15}{17}$

"The above figures would be for unfiltered radiation, of course. With one millimeter of aluminium filter, nearly twice the above might be administered with reasonable safety *once in three weeks*. With two millimeters of aluminium as filter the safety factor would be somewhat greater but not yet absolutely so for *one application in three weeks in a goiter case*. Your client applied the above *four times at weekly intervals* and if this is not overdosage, what is it? And he then applied greater dosage after an interval of ten weeks, but for only two applications seven days apart.

"In regard to the location of the burn being under the anode stem of the tube, will say that this is possible *if the patient was not protected* from such radiation, as it is well and generally known that x-rays are emitted from the back of the entire anode as well as from all along the anode stem of the Coolidge tube. This was described in detail by Coolidge and Moore in April, 1916, in 'The General Electric Review,' under the title of 'Roentgen Rays from Sources Other than the Focal Spot in Tubes of Pure Electron Discharge Type,' and the same paper was presented at the meeting of the two national x-ray societies and published in two magazines of international circulation among x-ray workers. For this reason your defendant should have known about the existence of this condition. In this regard, the sketch of the Coolidge tube (Fig 1) you sent me is incorrect in that it shows the area 'behind the face of the anode' as

the 'inactive region,' whereas it is well known that this region is active and that *it does emit x-rays*. I am enclosing herewith a very crude sketch (Fig 2) which

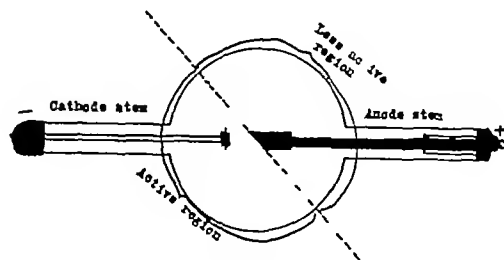


Fig 2

shows more correctly the distribution of the x-rays.

"Your assumption that the burn resulted from the rays emitted from the back of the anode and the anode stem may be true, but this is rather unlikely. In other words your theory is correct but this would probably not work out practically because not enough x-rays to produce a burn (with the technic used) should be produced to do much damage, and admitting the possibility that the damage was done by these rays from back of the anode face, *your client should have protected against such a contingency*."

"You say on page 3 in third paragraph, 'it is well to keep in mind that it is the long wave x-ray that does harm. The long wave length is due to a low voltage. In this particular case we were using about 5-in gap, or approximately 50,000 volts, which is very small in x-ray therapy.' According to Kaye, and verified by myself many times, a five-inch gap (using the usual blunt points fitted to modern apparatus) is equal to about 86,000 volts peak. According to others, it is equal to about 64,000 effective voltage. Modern radiologists compute voltage at peak volt value. And again, more x-ray burns are caused by high voltage and short wave length than by medium and low voltage and medium and long wave length x-rays. I not infrequently use a current of 45,000 in therapy. This gives about two and one-half inch spark gap, and is very efficient in certain skin conditions

"Replying to the question in Mr K——'s letter 'Could we not get some help from the manufacturer?' I take it that he means the manufacturer of the x-ray tubes, and in reply to that will say that it was the employees of the General Electric Co (Dr Coolidge and Dr Moore) who called our attention to the fact that x-rays are emitted from other sources than the focal spot of pure electron discharge tubes as previously stated

"To sum matters up as I see them from the information received from your letter, will say it is my opinion that

1 The dosage applied was excessive

2 Whoever it was who applied or prescribed such dosage displayed a lack of knowledge of the proper treatment of goiter, as well as carelessness in failing to protect against the effect of the x-rays which were emitted from the back of the anode and the anode stem

3 (a) Your theory of how the burn was produced is untenable

(b) If the theory was tenable, your client should have known that he must protect against its effect

4 Probably no competent expert witness will hold with your claims

"As regards to my offering suggestions, will say that as I see it, you 'have no leg to stand on,' so that, as much as I dislike even the consideration of a settlement, it seems to me that settlement is the only sensible thing to do in this case "

This case came to trial in due time and, as might be expected, resulted in a verdict in favor of the plaintiff with judgment for \$5,000 damages and costs. I did not attend the trial. The case was then taken to the state supreme court on an appeal.

While it is clearly evident to anyone at all familiar with the subject that the defendant was guilty, and the jury found him so, the supreme court (with one judge absent and another dissenting) decided to reverse the judgment and remand the case with instructions to dismiss plaintiff's complaint. However, the case was reviewed by this court, and later remanded to the lower court for retrial as related later.

Because of the importance of this decision it is quoted almost verbatim<sup>3</sup>

"The defendant is a physician and surgeon in the practice of his profession in the city of F——. Early in the Spring of 1925 he undertook the treatment of a toxic goiter from which the plaintiff was suffering. He gave her alternate treatments of the x-ray and the actinic ray. He gave a treatment of each ray once a week for a period of five weeks, when he went to Europe and was absent for about ten weeks. During the period of treatment her condition improved steadily and satisfactorily, and no untoward results of the application of the treatments were observed. No burn resulted and there was nothing to indicate that her skin was hypersensitive to the rays. While in London attending a meeting of a medical society, the defendant was told by a doctor that if he would remove one filter from the x-ray machine he would secure quicker results. Upon his return from Europe, he renewed the treatments in exactly the same manner that he had administered them before his departure for Europe, except that in administering the x-ray he used but one filter in the machine instead of two. His first treatment after returning from Europe was administered on July 21st, in the evening. During that night the patient noticed a soreness and burning at the side of her neck along where the treatment had been administered, and in the morning it was still swollen. During that day the swelling went down, and it seemed to feel better, and she paid no further attention to it. This treatment was given on Tuesday. On Friday night she called on the defendant, told him of the soreness of her neck, that it had swollen and 'kind of burned,' but that the swelling had gone down. She said she thought perhaps she had taken a cold. On

<sup>3</sup> It is extremely important to note that the published report of this decision in the N. W. R. is as here quoted. The fact that this case was re-argued before the same supreme court and that a second decision was that the case be remanded for retrial and that it was settled before the second trial is not on record. As far as the writer knows this is the first publication of these later facts.

that night he gave her an application of the actinic ray. She noticed no ill effect from that treatment. The following Tuesday, the 28th, she returned to him for an x-ray treatment. At that time nothing was said about the soreness of her neck. During the treatment on the 28th she noticed a sort of prickling sensation, but 'it wasn't bad', that was all she noticed while she was in the office, but during the night she woke up and there was 'a terrible soreness and burning' on her neck. The next morning she went to his office and asked him what had happened to her neck. He told her that she had an x-ray burn, which he treated with the actinic ray. He continued to treat the burn with the actinic ray until October 5th, after which she consulted another physician.

"It appears uncontradicted by the expert testimony in this case that an x-ray burn is due either to overdosage or to a hypersensitive skin, and that there is no way of diagnosing in advance whether the skin of any individual is hypersensitive to the x-ray. It is fundamental that, in order to recover in this case, the burden is upon the plaintiff to prove negligence on the part of the defendant in administering the x-ray treatments. In order to support the conclusion that the burn was the result of defendant's negligence, it is first claimed that the treatment given prior to the defendant's departure for Europe resulted in no burn, and disproves the fact that the plaintiff had a hypersensitive skin. The defendant admits that in administering the treatment upon his return from Europe he used only one filter in his x-ray machine instead of two, and that this resulted in greater dosage, but this does not prove that the dosage given after his return was an overdosage, or that the dosage given prior to his departure was a normal dosage. It simply proves that the dosage given in the later treatments did burn the skin. It leaves entirely to speculation whether the burn was the result of an overdosage, or whether it was due to the hypersensitivity of the skin. There is no evidence in the case to establish the fact that the dos-

age from which the burn resulted was an overdosage.

"It was the defendant's duty to exercise that degree of care, diligence, judgment, and skill which physicians in good standing in the same school of medicine usually exercise in the same or similar localities, under like or similar circumstances, having regard to the advanced state of medical or surgical science at the time he discharged his legal duty to his patient. In order to hold him liable, the burden is upon the plaintiff to show that he failed in the requisite degree of care and skill. That degree of care and skill can only be proven by the testimony of experts. Without such testimony the jury has no standard which enables it to determine whether the defendant failed to exercise the degree of care and skill required of him. [Citing cases.]

"*The doctrine of res ipsa loquitur is not applicable to malpractice cases between patient and physician* [author's italics]. The reason for this rule is stated clearly and tersely by Judge Taft, in *Ewing vs Goode*, 78 Fed. 442, in the following language:

"A physician is not a warrantor of cures. If the maxim, "*res ipsa loquitur*," was applicable to a case like this, and a failure to cure were held to be evidence, however slight, of negligence on the part of the physician or surgeon causing the bad result, few would be courageous enough to practise the healing art, for they would have to assume financial liability for nearly all the "ills that flesh is heir to."

"There is some disagreement in the authorities as to whether this doctrine applies where results such as arise from x-ray treatments. *We can see no reason why the same rule should not apply to x-ray treatments given by a physician to a patient for curative or healing purposes* [author's italics]. The discoveries of science are continually placing in the hands of physicians new agencies with which to cope with disease. Among such discoveries came the x-ray. It is, undoubtedly, a valuable healing agency, and is coming into quite general use by physicians for treating and curing diseases. Where physicians minister these treat-

ments for curative and healing purposes—where the *bona fide* relation of physician and patient exists—we see no reason why proof of a bad result should constitute proof of negligence on the part of the physician, any more than when any other agency is applied or administered. It is said that the x-ray is a dangerous agency, but, as said by the Pennsylvania court, 'So is a surgeon's knife. If human ills are to be cured, such instrumentalities must be used. To put upon the medical profession, which must use them, such a burden as the financial responsibility for damages, if injury or death results, without proof of specific negligence, would drive from the profession many of the men who should remain in it, because unwilling to assume the financial risks.'

"The great weight of authority holds that the doctrine of *res ipsa loquitur* does not apply under such circumstances. *Sweeney vs Erving*, 35 App D C, 57, 43 L R A (N S), 734, *Antowill vs Friedman*, 197 App Div, 230, 188 N Y Sup, 777, *Runyan vs Goodrum*, 147 Ark, 228, S W, 397, *Nixon vs Pfahler*, 279 Pa, 377, 124 Atl, 130.

"In the instant case there is not only no evidence to show that the defendant administered an overdosage of x-ray to the plaintiff, or that the defendant was in any respect negligent in administering the treatment, but the defendant himself testified as follows upon that subject:

"Of the standard authorities that medical men using this kind of instrument follow in this locality, Remer and Witherbee is considered one of the best, and Sampson is another. Remer and Witherbee have developed a formula for every size filter for goiter cases. The technic I used conformed in every respect to the formula of Remer and Witherbee, as to spark gap, milliamperes, time, and filter. The time, filter, and distance that I used were within the factor of safety of those rules. The next treatment that I gave was given just exactly the same. The technic and formula that I used conformed to medical standards in this locality.

"There may be some doubt as to

whether the contents of medical works can be intruded in evidence in this manner, but the defendant's statement, that 'the technic and formula that I used conformed to medical standards in this locality,' being undisputed, must be accepted as the standard of the care and skill required of him, and there being no evidence to show that he did not meet this degree of care and skill, there is no evidence to support the verdict for plaintiff.

"Some stress is placed upon the testimony of plaintiff that the Doctor told her that the burn was not the result of accident, but that it was due to a lack of knowledge. It is admitted in the case that the Doctor withdrew one filter from the x-ray machine because of the advice received by him from the physician in London. If the withdrawal of this filter was, in fact, bad practice, the mere circumstance that he was advised so to do by the doctor that he met in London would constitute no defense. If, as a matter of fact, it was the proper practice to withdraw the filter, then it matters not what or who induced the Doctor to pursue the practice. His ignorance is immaterial if his practice is right.

"From what has been said, it follows that the court erred in the following instruction to the jury: 'If you believe from the evidence that, when proper care is used in administering the x-ray in the treatment of goiter, a burning of the patient to the extent here shown is not likely to result, under all the circumstances here involved, then the fact that plaintiff was so burned may be considered by you as evidence that the defendant did not use due care and skill and judgment in administering the x-ray to plaintiff, but in determining this fact you must also consider all of the testimony of the defendant as to proper practice, and dosage and what dosage he, in fact, administered, and decide upon all the evidence bearing upon the point.'

"This charge told the jury that the fact that plaintiff was burned may be considered by them as evidence that the defendant did not use due care, skill, and judgment in administering the x-ray to plaintiff.

In view of what has been heretofore said, it is apparent that this statement was erroneous

"Judgment reversed and cause remanded, with instructions to dismiss plaintiff's complaint "

This case was re-argued before this same supreme court, after which it was remanded to the district court for retrial. It was settled for \$2500 before the second trial came up. If the writer is in the least manner competent to give an opinion, the defendant and his insurance carrier got off cheaply.

It will be recognized that the foregoing opinion, by the Supreme Court of Wisconsin, is one of the best and most favorable ones on record, as far as roentgen therapy and roentgen injuries are concerned, ever given in any court anywhere. It must at the same time be clearly evident to anyone at all acquainted with roentgen therapy, that the defendant in the case was guilty of malpractice as we know the subject of roentgen therapy of toxic goiter—or, in fact, almost any except malignant disease—and that the jury was correct in finding him so. In all due deference to the learned judge of that supreme court, we who know more about the subject than he can and does, need only read the third and fourth sentences of the opinion to realize that the judge was reasoning from false premises, and consequently his first conclusions must have been and were wrong. Evidently the erroneous instructions of the trial judge to the jury (see third from last paragraph of supreme court decision) was the deciding point for the supreme court's first decision.

It will be well for all who have to plan a defense against a suit of this character, to remember this case. It is loaded with much that will help defend and defeat charges of malpractice due to roentgen injuries.

#### ANOTHER GOITER CASE

In 1929 I received the following letter from a medical friend in central Illinois: "Some time ago I treated a patient over the thyroid by means of roentgen ray, us-

ing three portals, one on each side and one over the median line just below, bringing the edges of each surface treated in close approximation to the other two. I used the following technic: 0.23 wave length, 241.8 r, over each area at one sitting, obtained by the following factors: ma 5, kv p 120, distance 20 cm, time  $7\frac{1}{2}$  minutes, portals  $3\frac{1}{4}$  cm.

"Realizing that a small amount of filter should be used, I would appreciate your opinion of the skin effect and the ultimate outcome of this amount of unfiltered rays.

"Any suggestions or references will be appreciated."

I immediately replied: "From the technic and figures given, it is my opinion that the skin effect would be the production of a rather marked first degree or a mild to moderate second degree roentgen dermatitis, and that the ultimate outcome of that amount of unfiltered radiation on the average skin would be pigmentation, followed, after a more or less extended period, by telangiectasis and skin atrophy, after healing of the primary dermatitis.

"The foregoing opinion is based upon the assumption that the skin of the patient is of average or normal tolerance and that the figures given are absolutely correct. If there is an hypersensitiveness of the skin of the patient, the effect would, of course, be exaggerated, while, on the other hand, if the skin of the patient be more than usually tolerant, there would be only a slight erythema, followed by slight pigmentation, which would disappear after a lapse of a more or less prolonged interval.

"I am wondering somewhat, why you are asking me these questions, and why you used unfiltered radiation in a goiter case. Surely you do not expect to treat patients with goiter, without the interposition of some filter between the tube and the patient's skin.

"Trusting that the above answers the questions and that I may be useful if you are in trouble, "

In a few days I received the following: "Thank you for your early reply to my letter and the extent you went into the

case I assure you that this is greatly appreciated

"This being my first case in which I have the misfortune to neglect interposing a filter, it was noticed immediately after the treatment was finished. I am glad to admit that my experience with x-ray dermatitis is very limited. This will probably explain the reason for writing you in the matter

"The matter is in the hands of the of , who have gone so far as to file an answer. So far, it has been kept out of the papers. Believe it will be settled before going to trial.

"The patient has a healed scar over the area of treatment. She received sufficient radiation to cause a destruction of the skin, just as you said, which healed in about six weeks."

Two weeks after receipt of the last quoted letter, I was visited by the husband of the plaintiff and her attorney, and I was importuned to appear as an expert witness for them. They offered to pay me well for my services, but when I informed them that my fee would be one thousand dollars per day and expenses, payable in advance, they concluded that they did not care for my services.

This case was settled out of court, before it came to trial, for \$3,800, and is another reason why we therapeutic radiologists have to pay such high rates for malpractice insurance. The insurance companies get "soaked plenty" and we have to absorb the "*quod hoc*."

#### A NEW SHARP TRICK

There is something new under the sun. An eastern radiologist recently wrote me "In an article in the May, 1935, issue of RADIOLOGY, there is a footnote in which you said that you would give advice to anyone wishing to know how to avoid having to give expert testimony after being called to the witness stand, merely to identify films. I would appreciate the information.

"I recently had an experience which exasperated me considerably. A liability case came to court, in which the defendant

was bringing suit against the insurance company because of non-union of a fracture through the shaft of the tibia. The insurance company referred the patient to a country physician, whose experience with fractures was limited and whose knowledge of x-ray interpretation was nil. This physician in turn referred the patient to me for x-ray examination, which I made and gave a written report to him. When the case came to trial, I was subpoenaed to identify the films only and the country physician followed me on the stand as an expert witness, using my report as a basis of his testimony. The reason for such a procedure on the part of the attorney for the insurance company was twofold. First, the country physician was notorious for his ability to testify as desired by the attorney, and second, his fee as an expert witness was quite low. I would appreciate any suggestions from you, as to how I might avoid such situations in the future."

I replied "Yours of last Saturday received. Yes, there is a footnote below my paper in May RADIOLOGY. In fact, there were several of them. If you will refer to page 567, which is the one to which I believe you refer, you will find that you did not read all of it. However, I am enclosing the instructions mentioned and trust that they may be of some use to you, as they have been to me and several others. At the end of that same paper is another footnote which I think will interest you.

"I thought that I had come upon about all of the sharp tricks of the crooked lawyers, but evidently there are some of them that I still must learn. Your recital of how they turned a country physician into an expert witness and into interpreting your roentgenograms is a new one on me. However, it should not be at all difficult to 'fix his clock.' If you have the attorneys for the other side of the case dig into his training and qualifications as an expert, it should be easy enough to have his testimony shot so full of holes that it would look like a sieve. If I had it to do, I am sure that I could have it and him torn to shreds as far as his posing as an expert,



*unless he knows his stuff* By this means—of showing him up or forcing him to show himself up to the judge and jury—there should be little difficulty in having his testimony practically erased from the evidence in the case, and if the case is decided against the side you favor, his testimony of itself would be enough to produce a reversal by the higher court

"I am unable to find anything in the cases of this sort from your State. If you will look up *Sheldon vs Wright*, 80 Ver R, 298, 67 Atl R, 807, or *Liles vs Hannah Picket Mills*, 17 S E R (2nd), 233, you may find something that may help

"As a general rule, it is becoming more and more evident that the courts are expecting roentgenograms to be interpreted by experts and it is only a question of time until this will be the rule and only those who can qualify as experts will be permitted to interpret them in court. Of course, you and I know that that is as it should be

"I am sorry that I am unable to give you anything like definite advice in your dilemma, but I trust that the above may help "

#### LAYMEN AND TECHNICIANS AS EXPERT WITNESSES

In 1932 a well-known roentgenologist in New England wrote me "May I be so bold as to call upon you for some help? Within a year in this State, on two occasions, one only a week ago, a superior court judge allowed an x-ray technician to qualify as an expert and interpret x-ray films as to the presence of fracture, this particular case being one where there was a question of skull fracture

"The practice of medicine has not been defined in this State. Will you please tell me how to go about the hunting up of legal opinions on the qualifications of experts? Have you any material at hand that you could loan to me? Is there a law digest that might help me in this situation?

"I think the matter should be brought to the attention of our local and national societies and an extensive drive be made

"Any help that you may give me will be greatly appreciated "

I replied "Yours, etc, and as I am in the midst of preparing a paper which touches upon the very question you are asking about, I am glad to be able to reply so soon

"The giving of expert testimony by technicians is becoming more and more common all over the U S and it is difficult to outline a plan to beat them. I have once knocked the testimony of a layman who has for years testified as an expert, by giving the opposing attorneys a list of questions in anatomy, which they should ask the offending layman. These questions were germane to the subject to which he testified, but he was unable to answer any of them correctly, and the result of this strategy was to completely nullify what he said about the x-ray films in question. I believe that if you and your confrères would plan something of that sort, you could soon prove to the offender that it does not pay to pose as an expert

"Your question as to whether there is a 'law digest' induces me to say that there should be one of legal medicine or medical law, but unfortunately there is none that would be of much value to us. There are, of course, numerous digests, but none of what we want and need. I have in preparation a review of 85 Supreme and Appellate Court decisions, some of which are along the lines you seek, which I expect to have published in one of the two leading x-ray magazines shortly

"I have given the legal side of medicine—particularly of our specialty—more study than any one I know of and believe that I am in as good a position to discuss these things as any one we have. I do not say this to brag, but I believe that the older men in our work recognize this to be true

"But to give you something more specific about your situation *Liles vs Hannah Picket Mills, Inc*, 17 S E R (2nd), 233, is a North Carolina Supreme Court decision in which the court said 'The testimony of a witness explanatory of a roentgenogram was properly excluded in a finding by

the court that he was not sufficiently qualified to express an expert opinion on questions of anatomy in connection with the proposed explanation'

"You should also secure considerable material of benefit from a review of the following decisions

Rosecoe Stevens *vs* Ill Central Ry Co,  
134 N E R An Illinois case  
Daniels *vs* Iowa City, 183 N E R, 415  
An Iowa case  
Ligon *vs* Allen, 181 S W R, 656, 657  
A Kentucky case  
Kassoff *vs* Kupperburg, 154 N Y Supp,  
149 A New York case  
Sheldon *vs* Wright, 80 Ver R, 298, 67  
Atl R, 807 A Vermont case, which is  
liable to be of considerable value to  
you as it involves just about what you  
want

"I might go ahead and cite you dozens more of these decisions, some of which might give you only a line or two that would be of value, but I am sure that you will find sufficient to at least start you along the lines you seem to want

"Assuring you that it is always a pleasure to be of use to my friends, and that I will be glad to learn how you succeed in your affair," etc

We have little or no fault to find with the introduction and identification of roentgenograms by technicians, in fact, many roentgenologists prefer to send their technicians to identify their films, but when it comes to interpretation and the making of diagnoses, we have most strenuously objected and expect to continuously continue to object in that such practice must end

At this time, with so much discussion relative to the roentgen diagnosis of pneumoconiosis, is a good time to rise up in our wrath and start a campaign against uninformed laymen testifying as experts in roentgenology

It has been our experience that cheap, puff-blowing lawyers are the most likely to employ these non-medical witnesses as experts, and a concerted action by medical radiologists along the lines indicated in the

foregoing, besides seeing that leading questions regarding medical training, medical degrees (or the lack of same), membership in medical societies, special societies, etc, should go a long ways toward convincing the lawyers that their technicians' testimony is worthless and that it is useless for them to continue employing them

Unquestionably, the lawyers who employ and make use of these non-medical witnesses and technicians who testify as experts are as much or more at fault as are the witnesses themselves. Much of this may be due to the fact that these lawyers undertake to prosecute many (if not nearly all) of the suits wherein such witnesses may be used, on a contingency basis, and as so many of such suits have little or no real merit, it is difficult to find honest, upstanding medical experts who will testify as the lawyers want them to. This is not entirely true, however, as is evidenced by a recent example in the writer's experience

An attorney for an industrial institution recently called upon the writer and asked for interpretation of two roentgenograms. When informed that both thoraces in the roentgenograms showed findings strongly suggestive of pneumoconiosis, he evinced definite disappointment. He said that a local technician had that afternoon testified that one of the films showed shadows produced by iron or stone dust in the lungs, and that he had hoped I would disagree with that finding. When I told him how I would attack the testimony of the technician, by discrediting him and his testimony, he responded that that would not avail or be of any benefit unless he was able to put a convincing medical expert witness on the stand who would testify that the technician's testimony was wrong, incorrect, and therefore not to be believed. Of course, I could not send him to any of that sort, because the pneumoconiotic deposit was clear and evident in the films, and even though I knew one or two—better say several—medical men who for fifty dollars would be very likely to swear to almost anything. I told my legal friend that and he admitted that he also knew several

medical men who would give the kind of testimony he sought, but he did not want that kind of testimony from that kind of witnesses

This phase of the situation must be handled differently, and it seems that the only feasible way it can be properly and successfully coped with is to influence the courts into understanding that only trained and properly qualified medical experts should be permitted to make diagnoses and interpret roentgen findings. They would not permit laymen or non-medical technicians to diagnose scarlet fever, diabetes, or appendicitis then why permit these same persons to diagnose other, much more complicated, diseases or pathologic conditions? I have told judges—in conversation, out of court—that they have no more right to permit laymen to interpret roentgenograms than they have to allow them to make diagnoses of syphilis, typhoid fever, Bright's disease, or pneumonia. This has stirred up some discussion, but it has been our opinion that some of our argument would grow where it was planted. If all of us would plant that sort of seed at every opportunity, it would not be long before we would see a sprout here and there. It is by keeping everlastingly at it that we will accomplish our end. We have seen this in our long-contested claims to the ownership of the roentgenograms, which have finally culminated in a state supreme court decision along the lines that we have claimed, and advocated for many years. The road may be long and hard, and even "beset by ruffians," but right will prevail, and will win if continued effort is persistently maintained.

WAS IT INFANTICIDE? NO, THE BABY HAD NOT BREATHED!

The utility of the roentgenogram, to ascertain if an infant has ever breathed or not, has been applied a few times to determine the possible guilt of young (and older) mothers. An instance of this kind occurred in the writer's experience many years ago.

A young woman, pregnant and at term, had a very violent altercation with her husband, late one evening. He arose from the bed and the following morning was found by his wife, dead in the bath room, with the gas heater turned on.

Naturally, terribly shocked, she ran to her bed. The shock probably induced a precipitous labor, as she was found in bed with a dead baby beside her the following evening. Her husband's mother, who found her, summoned the police, and the policeman who first arrived being a patient and friend of mine, called me.

The mother-in-law, in her frantic grief over the death of her son and possibly for some other reason, suddenly screamed out that the young mother had probably smothered her baby. This charge naturally introduced a new and, to the deputy coroner, perplexing uncertainty into the situation.

The policeman, again wishing to push the writer to the fore as much as possible, asked me if I could determine whether the baby had been born alive. Not being so very backward or bashful myself, I offered to try to determine if the infant had breathed or not, and, with the consent of the deputy coroner, took the dead infant to my office, which was only a few doors away around the corner, and made several roentgenograms of the thorax of the baby. I found that the lungs were completely atelectatic and, at the coroner's inquest, reported to the jury that the child had never breathed, thus establishing the facts in the case and relieving the young mother from what looked like a possible charge of infanticide.

CONTRIBUTORY NEGLIGENCE OF PATIENT  
KEEPING OF RECORDS

In 1910, a man who had been treated by a drugless healer (*quid rides?*), and had suddenly lost consciousness after a neck-wrenching application of the therapy, applied to his family physician for relief for a "stiff neck." The physician after looking the patient over directed that he come to his

office in a few days. The patient did this, and in the presence of his office attendant, the doctor directed the patient to go to my office for x-ray examination, at the same time calling me by telephone and telling me about the case.

I made a note upon my desk pad, informing my technician that I wanted to make the examination myself. The patient did not come in as per his appointment and I forgot all about the matter.

This patient deserted the treatment of the first physician and went to another, who also sent him to me for roentgen examination. This time he came and my plates revealed a fractured arch of the axis. Naturally he was put into a jury mast apparatus, which he wore for several months, and had a pretty bad time.

A few months later, this patient brought suit against the first physician for malpractice, alleging among other things that he had neglected to use the x-rays in "ascertaining the diagnosis," etc. Shortly before the trial of the case the defendant physician visited me in my office and told me about the case, and reminded me about his having called me over the telephone, making the appointment for this man to have his neck examined. I looked up my desk pad and found the notation before mentioned, and, after a conference with his attorney, who thought he might be able to introduce our telephone conversation in evidence, it was decided that I was to appear as a witness at the trial.

At the time of the trial the defendant testified that he had directed the plaintiff to go to my office for x-ray examination. His office nurse testifies that she had heard the foregoing instructions given to plaintiff by defendant. When I was called to the witness stand I was allowed to testify that I had had very many telephone conversations with the defendant physician, that I did what x-ray diagnosis he had done, that I could positively identify his voice over the telephone that he had made an appointment on a certain date for me to make x-ray examinations of the neck of a certain Mr. Blank that I had made

written notes of that appointment, and that Mr. Blank did not appear at the appointed time. It was further brought out that the same Mr. Blank was sent to me by another physician and that I did examine the plaintiff for the second physician several weeks later.

Of course, the defense alleged contributory negligence, because the plaintiff failed to follow instructions and have his neck examined by the x-rays as directed, such instructions being proven to have been given by the testimony of defendant, his employee, and the writer.

The trial judge, in his instructions to the jury, directed them to bring in a verdict in favor of the defendant, *if they found that the plaintiff had contributed to his poor condition by failing to obey the defendant's reasonable instructions and directions*.

The jury, within a few minutes, brought in a verdict for the defendant physician with a judgment for the amount of his fee. Application for a new trial was denied by the judge. The case was not appealed, as this was too evidently a case of contributory negligence.

This was an interesting and unusual instance wherein the writer happened to be the roentgenologist of two physicians who had been "at daggers' points" for years, but who at that time learned the folly of their ways and became fast friends and are such to this time.

The foregoing is an important lesson on the value of making and preserving notes and records. The writer has always made copious notes and kept careful records and has advocated the value and importance of making and keeping records, so again he says, *make records at the time you do a thing and keep the records until after the act recorded has been outlawed*. We have in our files, records of examinations made more than twenty years ago of infants and small children, who, because of their age might bring malpractice or other damage suits at any time within two years after reaching their majority. Several of these records and roentgenograms are of birth fractures which must be kept until the patient of

whom they were made becomes twenty-three years old

Under the title of "How Long are We Liable?"<sup>4</sup> the writer called attention to an instance wherein a physician had been sued for malpractice sixteen years after rendering services. This should prove to skeptics that the precautions taken and herein advocated are not at all unreasonable nor far-fetched. *Operæ pretium est*

#### ESTIMATION OF r UNIT LOSS AND DEPTH DOSE TABLES

A western radiologist who was being sued for malpractice asked me for my working tables of dosage or radiation retention, and for depth dosage delivered at various depths at 140 kv and 200 kv. My reply read:

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The recipient of these tables was most profuse in his thanks, and said that he thought every radiologist who does any therapy should have both of them framed and posted at every control stand. He further said that the unit loss table was largely instrumental in his being able to convince the jury that he had not administered an excessive amount of radiation, and thereby enabled him to secure a "not guilty" in his malpractice suit.

#### AN UNUSUALLY THIN CRANIAL VAULT

About thirty-three years ago, while acting as police surgeon in Omaha, the writer was called to examine a prisoner who had been brought into the "hoosegow" very much under the influence of liquor. Upon

#### ESTIMATION OF r UNIT LOSS AFTER TREATMENT

Days after Treatment		Estimated Amount of Radiation in r Units Retained							Percentage Returned		Days after Treatment	
Day	%	550	500	450	400	350	300	%	Day			
1	5	522	475	427	380	332	285	95	1			
2	10	495	450	405	360	315	270	90	2			
3	15	467	425	382	340	297	255	85	3			
4	20	440	400	360	320	280	240	80	4			
5	25	412	375	339	300	262	225	75	5			
6	30	385	350	315	280	245	219	70	6			
7	35	357	325	292	260	227	195	65	7			
8	40	330	300	270	240	210	180	60	8			
9	45	302	275	247	220	192	165	55	9			
10	50	275	250	225	200	175	150	50	10			
11	55	247	225	202	180	157	135	45	11			
12	60	220	200	180	160	140	120	40	12			
13	65	192	175	157	140	122	105	35	13			
14	70	165	150	135	120	105	90	30	14			
15	75	137	125	112	100	87	75	25	15			
16	80	110	100	90	80	70	60	20	16			
17	85	82	75	67	60	52	45	15	17			
18	90	55	50	45	40	35	30	10	18			
19	95	27	25	22	20	17	15	5	19			

#### RELATIVE DOSE DELIVERED AT VARIOUS DISTANCES UNDER THE SKIN

Depth below Skin	140 K V P 15 in F S D 5 mm Al Filter (Dose is 475 r)	200 K V P 20 in F S D 0.5 mm Cu Filter (Dose is 350 r)
(cm)	(%)	(%)
0	100	100
1	98	99
2	91.5	93
3	80	87
4	76	80
5	62.3	77
7	46	56.6
10	30.8	38
15	14.4	20.7

trying to arouse the apparently stuporous man, it was noticed that the pupils of his eyes were unequal, and further examination gave strong suggestions of intracranial hemorrhage.

This prisoner-patient was immediately transported to a hospital and further examination disclosed a depressed cranial fracture. He was prepared for a decompression operation, and as the surgeon's trephine opening was made the patient stopped breathing, all efforts to resuscitate him failing.

All of this occurred before the patient

<sup>4</sup> RADIOLOGY April 1935 p 500

was identified. He was immediately taken to the morgue. Postmortem examination disclosed that death was due to a depressed fracture of the left parietal bone, evidently the result of a blow on the head. The skull, particularly the parietal bones, was found to be extremely thin, and the writer casually and without definite purpose appropriated a fragment of the fractured parietal bone because of its extreme thinness.

Relatives of the dead man appeared and claimed the body, and brought a charge of murder against the policeman who had arrested the dead man, charging that he had unnecessarily slugged him with his locust club. Things looked rather bad for the policeman, as he had a reputation of being quick to use his club on recalcitrant prisoners. The policeman was bound over to the criminal court for trial on a charge of manslaughter.

At the time of the trial, the pathologist who had made the postmortem examination was ill and in bed with pneumonia and consequently unable to appear, and his autopsy protocol was introduced by the defense. Having been the first one who attended the dead man, I was called as a witness by the prosecution, and, remembering about the thinness of the skull, took the piece of the parietal bone with me, and

in the course of my testimony mentioned that I had it.

After the state had finished with my testimony, the defense made me its witness and I was caused to present the piece of bone, and the defense had it introduced in evidence (as an exhibit). After I had been excused, three teachers of anatomy were caused to testify as to the very unusual and extreme thinness and unusual liability to fracture from a lighter blow than would fracture an ordinary skull, etc.

The policeman was able to produce witnesses that the dead man was fighting drunk, that he was an habitual drunkard and when in that condition became very quarrelsome and violent, and that the blow struck by him was not a hard one, and when on the stand himself, testified that it was necessary to club the man into submission.

The jury acquitted the policeman, and his family fell on the writer's neck and wept with joy because I had saved the fragment of parietal bone, insisting that I had thereby saved their husband and father from probable conviction.

To the writer, it is just a case of "away back when" honest expert testimony saved a man from undeserved punishment.

*(To be continued)*

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<sup>4</sup> RADIOLOGY April 1935 p 300

hours to each of two anterior and two posterior fields on the pelvis (3)

In some instances 200 kilovolt x-ray apparatus supplied the external radiation instead of the radon pack and the factors used were 200 kv, 4 ma and 0.5 mm copper filter, which gave an effective wavelength of 0.16 Å. Two anterior and two posterior ports were radiated at a distance of 80 centimeters. In 1922, the current was raised to 8 milliamperes and more external radiation was given. In about 1924, the first attempt was made to divide the total dose of x-ray into smaller increments given over a period of several days. In the latter part of the first period, the treatment consisted chiefly of radon tubes inserted into the cervix in addition to the external application of x-rays to the pelvis.

The results of this method of treatment, grouping the patients according to Schmutz (4), are as follows

417 Cases	Percentage of Cures
Group I	62.5
II	27.7
III	13.2
IV	1.1
V	6.5

During the next five years, or second period, the intracavitary treatment was similar to that preceding it. With the introduction of the water-cooled x-ray tube, the current for the 200 kilovolt x-ray was stepped up to 30 milliamperes, and, at about the same time, gold radon seeds were introduced directly into the cervix. The technique for this combination of therapy can be briefly summed up as follows.

On the day of admission the patient received 480 roentgens, applied to the anterior pelvis. The factors were 200 kv, 30 ma, filter of 0.5 mm copper, field 20 × 25 cm, distance 80 centimeters. On the following morning under gas and ether anesthesia, a biopsy was obtained. The cervical os was dilated and the uterus curetted. Radon tubes of approximately 100 millicuries each with 1 millimeter platinum filter were placed in tandem in the uterine cavity and allowed to remain for an average dose of 2,400 millicurie-hours. Interstitial radiation in the form of gold radon

seeds having a wall thickness of 0.3 millimeter was also used in the cervix. Seeds of from 1 to 2 millicuries were used, and the total dosage depended entirely upon the diameter of the tumor, varying from 1,600 to 2,400 millicurie-hours. If upon calculation sufficient radiation had not been administered, another dose of 480 roentgens was applied to the posterior pelvis with the same factors as those for the anterior pelvis. In order to avoid overdosing the cervical-rectal septum, it is necessary to determine the amount of radiation which reaches that point from intracavitary, interstitial, and external radiation. For the intracavitary and interstitial radiation the amount at this point was estimated by means of factors, as outlined by Mattick and Stenstrom (5). For the external radiation the customary isodose charts were used. Practical experience has shown that this area will tolerate one and one-half skin erythema doses. Often it was found necessary to repeat this cycle of radiation after three months.

Among the complications incident to these therapeutic procedures, may be mentioned the dissemination of infection as a result of seed implantation, but in our experience this is rare. Another complication is the formation of fistulae, but when most of the cases treated are far advanced, this complication is to be expected if an honest effort is made to combat the disease.

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IN 1936, 955 CASES (INCLUDING THE 417 PREVIOUSLY REPORTED)

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In comparing these figures, there is a gain in Group I of 0.96 per cent, in Group II, 18 per cent, in Group III, 34.8 per cent, and in group V, 56.9 per cent. Group IV shows a loss of 0.91 per cent which is insignificant. These results show an improvement in percentage except in Group



# RADIATION THERAPY IN CANCER OF THE CERVIX

By LOUIS C KRESS, M D , F A C S , and M C REINHARD, M A , Buffalo, N Y

From the State Institute for the Study of Malignant Disease, Buffalo, N Y , Burton T Simpson, M D , Director

**M**OST discussions of cancer of the cervix deal with etiology, symptomatology, diagnosis, and treatment. The first three are important, but this paper will deal entirely with the last, namely, the types of treatment which have been used at the State Institute for the Study of Malignant Disease, in Buffalo, since 1913, with a report of some of the end-results. The treatment of this disease is primarily a radiologic problem, either radium or x-ray can be applied to the cervix both externally and internally and, since the response of the tumor is in part proportional to the amount of radiation applied, the trend has been to increase the total amount of radiation delivered into the organ.

In evaluating the end-results of any form of treatment, it is customary to include only those patients who have been under observation for at least five years. Nevertheless, since radiation methods have been changing so rapidly, a consideration of the treatment of patients who have been observed for less than five years may be of value from time to time. Unfortunately, at our Clinic, a large majority of the patients are suffering from far-advanced lesions, making it even more difficult to evaluate the improvements in technic under these circumstances. In dealing with this type of material, any improvement in the immediate results would be in the nature of a gain.

An endeavor has been made to divide the therapy given at this Clinic into definite period groups:

First	period—from	1919 to 1925 (1)
Second	—	1925 to 1930 (2)
Third	—	1930 to 1935
Fourth	—	1935 to the present time

The technic and results of therapy in the first two periods have been published (1 and 2) and will be reviewed very briefly

The third period deals with the use of 4-gram pack applications, the protraction of the x-ray treatments, and the internal application of radium tubes and radon seeds, the last period deals with the 45-gram radium pack, augmented by tubes, seeds, and x-ray.

In the first period, between 1919 and 1925, treatment of cancer of the cervix was rendered by means of radon tubes, radon pack, and 200 kilovolt x-rays. In 1913, the Clinic received a donation of 50 milligrams of radium from a prominent Buffalo woman who in the later years of her life suffered from carcinoma of both breasts. During 1920, 2 grams of radium were purchased and placed in solution, and in 1921 the first 200 kilovolt x-ray machine was installed. Therefore, because of the inadequacy of the therapeutic agents at hand at that time, it is needless to report what was accomplished prior to 1919.

The surgical preparation for the introduction of the intracavitary radiation will be omitted here because it is quite usual and familiar to us all. A biopsy specimen was, of course, obtained from each patient. Intracavitary radiation in the form of a 50-milligram radium tube filtered through the equivalent of 1.0 millimeter of platinum was used until 1920, after which time radon tubes were used, the dosage ranging from 1,400 to 3,100 millicurie-hours.

External radiation was applied by means of a radon pack, the rays of which were filtered through 0.5 mm silver, 2 mm brass, 1 mm aluminum, and 1 mm rubber. The pack was placed on the anterior and posterior abdomen for 6,000 millicurie-hours to each skin area. During 1922, the square pack was replaced by a rotating pack, and the filter remained the same with the exception of the silver, which was omitted. The dosage was about 5,500 millicurie-

hours to each of two anterior and two posterior fields on the pelvis (3)

In some instances 200 kilovolt x-ray apparatus supplied the external radiation instead of the radon pack and the factors used were 200 kv, 4 ma and 0.5 mm copper filter, which gave an effective wave length of 0.16 Å. Two anterior and two posterior ports were radiated at a distance of 80 centimeters. In 1922, the current was raised to 8 milliamperes and more external radiation was given. In about 1924, the first attempt was made to divide the total dose of x-ray into smaller increments given over a period of several days. In the latter part of the first period, the treatment consisted chiefly of radon tubes inserted into the cervix in addition to the external application of x-rays to the pelvis.

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IV, and methods must be devised by which more of those cases can be salvaged

The purchase of an additional 5 775 grams of radium in 1930 made possible the construction of a 4-gram radium pack. The use of this therapeutic agent for external radiation played a prominent part in the therapy of cancer of the cervix during the third period of 1930 to 1935. This was a period of experimentation to establish a suitable procedure with this instrument about which little was known at that time. A description of this pack has been published (6).

Protracted radiation was coming into vogue and that, together with the new pack, necessitated that some time be spent in orienting ourselves with respect to the two. A variety of technics were used, including one large anterior and one large posterior field with a radium skin distance of 15, 20, or 25 centimeters. The last, because of the low intensity of the radiation, was found to be impractical. At the shorter distance of 10 or 15 centimeters, the amount of radiation reaching the mid-pelvis was found to be inadequate to cope with the disease.

A four-field technic was next used in order to increase the amount of radiation reaching a point at the center of the pelvis. Two anterior and two posterior fields were used, the beams inclining slightly toward the mid-line. This resulted in an appreciable gain in relative depth dose, but, because this was not enough to eradicate the disease, this pack was discontinued in 1935.

In view of the recent knowledge concerning skin tolerance, it was found that many of these patients received inadequate treatment during the period from 1930 to 1935. All of these patients, however, were suffering with far-advanced disease, being in Group IV, and it is difficult to compare the end-results with those of the two previous periods in which all of the groups were represented. It must be said, however, that some of these patients treated with the four-field technic did get a regression of the cervical lesion, but the pelvic metastases were not influenced. The in-

tracavitary and interstitial radiation remained about the same, except that the element was substituted for radon.

The constant desire to deliver more radiation into the pelvis caused our physicist to design a new type of pack or bomb, which, according to accurate measurement, delivers 50 per cent more radiation at 10 centimeters depth than did the former 4-gram pack (7). In the construction of this pack, a method of three-field cross-firing was used. The pack was designed in order that the optimum depth intensity might be obtained in the pelvic region, and is especially adapted for use in the treatment of uterine, cervical, ovarian, bladder, and rectal lesions. The pack consists of three separate compartments each holding a tray  $3 \times 6$  cm. and containing 1.5 grams of radium. A skin distance of 10 centimeters is used. The rays from three sections are directed so as to converge from 4 to 12 centimeters below the skin. The three separate fields measure  $5.5 \times 9.5$  cm. with the long axes parallel. The compartments are separated from one another by 3 cm. of lead. The secondary filters at the base of the pack, which come in direct contact with the skin, are 1.0 mm. of copper and 1.0 mm. of aluminum. The base of the pack is curved so that it conforms quite well to the contour of the average pelvis.

To date, only 12 uterine patients have been treated with this pack, the reason being that the treatment consumes considerable time and the pack is used on patients suffering from cancer in other parts of the body. All of the patients thus treated were suffering from far-advanced cancer, all being in Group IV (Schmitz). Perhaps this was not a fair test, but if the results are satisfactory in Group IV, it seems logical to assume that the results in the earlier stages will be more satisfactory.

Of the 12 uterine patients who have been treated with this pack to date, seven were under 40 years of age and five were between 40 and 59 years, showing that the most favorable cases were not selected with regard to age or amount of involvement.

The pathologic grouping seemed to have no bearing on the result, as all types were encountered, from the pearl cell to the very anaplastic type of carcinoma.

Three methods were used, but the first two have been discarded and the third only is now in use. The first method consisted of 28 days of treatment, alternating anterior and posterior fields daily, so that the anterior pelvis received 14 treatments with one day intervening, and the posterior pelvis likewise. The length of treatment was 3 hours and 52 minutes, each application delivering 400 roentgens per field, each day of treatment. The calculated cumulative skin dose was 3,760 roentgens with a total tumor dose of 4,900 roentgens. The second method continued the treatment over a period of 50 days, 25 treatments anteriorly and 25 posteriorly, with a daily increment of 200 roentgens, requiring 1 hour and 56 minutes to deliver this dose to the tissues. Thus, 4,375 roentgens were delivered into the tumor with a cumulative skin dose of 3,530 roentgens. This method caused irritation to the bladder and quite a severe reaction near the trigone. Three days after completion of the treatment, the skin blistered and later peeled and tanned. The tumor was diminished after three months, but some remained, interstitial radiation was used in the cervix and intracavitary in the uterus. Last examination revealed induration in the left broad ligament area.

The remaining 10 patients were treated over a period of 20 days, with a daily increment of 500 roentgens per day which consumed four hours and 50 minutes. The details of the treatment will not be noted here, but the dosage varied between 4,900 and 5,500 roentgens in the tumor, and the cumulative dose on the skin between 3,530 and 4,000 roentgens. This, considering the varying sizes of individuals, is quite a constant average and the variation is not great.

During the first week of the treatment the patients experience nausea and vomiting, but these subside and physical improvement is noted. Skin reaction begins

to appear during the last week of treatment, first being evidenced as a definite reddening of the skin, or copper color, with the formation of vesicles and desquamation, reaching its peak about two weeks after the conclusion of treatment. These skin changes are only temporary and the skin again becomes normal.

While the results from this method are in some patients satisfactory, yet the desired results of a spectacular improvement are not noted. The first treatments were given in January, 1925, and following treatment four patients are still considered hopeless, two have died, four have received some palliation but not a total disappearance of the tumor, and one is a very recent case the result of which has not been determined.

This was an experiment in patients who were suffering from a type of growth which in our experience has not responded to other types of therapy, and an effort was made to try this type of radiation, believing that 50 per cent more radiation into the pelvis would give more gratifying results. Some of the patients in this series received further radiation three or four months after external radiation, four received intracavitary radiation by means of tandem radium tubes, one had interstitial radiation in the form of gold radon seeds, two received seeds and intracavitary radiation, and one intracavitary radiation and 200 kilovolt x-ray.

This is a very small group of hopeless cases, but the effort being made to help these unfortunate individuals will be continued, not alone in the cervix cases but in the far-advanced rectal, bladder, and ovarian cases as well. Our hope is that some day a suitable method will be devised whereby more of the far-advanced group will be salvaged. No glowing results have been set forth here, but only a report of an effort being made to find out how much more radiation can be delivered to the pelvis with the therapeutic agents at hand. At the present time we know of the results obtained with the use of higher voltage, by changing the wave length of the 200

kilovolt x-ray by means of heavy filtration, but again this is impossible with the set-up at our Clinic at the present time. Perhaps someone will find out what not to do, which is often as important as what to do.

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By PHILIP S AVERY, M D , *New Brunswick, N J*

SYPHILIS of the esophagus, like gastric syphilis or syphilis of other portions of the alimentary tract, presents many problems, the chief of which is probably diagnosis. Unfortunately there is little available information on this subject in the literature. While syphilis of the esophagus has been recognized for the past two centuries, there have been only occasional reports on the subject. One author states that there have been less than 100 cases reported, and of these, many are not proven or authentic. When we consider

- (1) No indications for operation and surgical-pathologic confirmation
  - (2) Amenability to treatment
  - (3) Similarity to other lesions and co-existence with them
  - (4) Difficulty in securing biopsy material
  - (5) Non-recognition of lesions by esophagoscopist or failure to make the esophagoscopic examination
  - (6) Infrequent postmortem confirmation—the esophagus is seldom examined
- We are again confronted by the problem



Fig 1 A First examination



Fig 1 B First examination

the problem from the diagnostic point of view, realizing how often it is almost impossible to prove this diagnosis, even when all signs point to this condition, it is not difficult to understand why there is such a paucity of authentic literature. Lack of confirmation of diagnosis may be attributable in large part to the following factors

of very few available statistics as to the incidence of syphilis of the esophagus. There is no doubt, however, that it is an unusual disease. We know that syphilis attacks the gastro-intestinal tract less frequently than other portions of the body, with the exception of the mouth and pharynx, and is less commonly found in the

kilovolt x-ray by means of heavy filtration, but again this is impossible with the set-up at our Clinic at the present time. Perhaps someone will find out what not to do, which is often as important as what to do.

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Fig 3 First examination



Fig 4 Second examination

importance in diagnosis. Patients rarely have pain though there may be some with laryngeal involvement. The onset of the dysphagia is gradual, often of from four to twelve months' duration, and dysphagia increases as stenosis becomes more advanced. The patient at first has difficulty only in swallowing solids, then semi-solids, and finally liquids. Loss of weight, anemia, and asthenia occur only in late stages and result from loss of food as well as from syphilitic toxemia.

The diagnosis is difficult. A carefully taken history is of extreme importance; it must rule out the possibility of chemical causes such as the swallowing of a corrosive, or the possibility of other trauma as a causative factor. A history of gradual painless onset with transitory periods of dysphagia followed by symptom-free periods is of importance. Diagnosis while still difficult has been facilitated in recent years by roentgen study, esophagoscopy, and serologic investigations. The x-ray

examination is of paramount importance; the well trained roentgenologist will usually recognize ordinary lesions and will differentiate between carcinoma and syphilis. Esophagoscopic examination is extremely important; unfortunately, many well-trained esophagoscopists, as well as roentgenologists, have seen few syphilitic lesions of the esophagus and are unfamiliar with their appearance. It is readily conceivable that syphilitic sclerosis of the esophagus with stenosis will present no characteristic findings on esophagoscopic examination. A positive Wassermann is, of course, important, but a negative reaction certainly does not exclude a diagnosis of syphilis of the esophagus. All available diagnostic facilities must be used and the findings supported by careful history and clinical study. All other diseases to which the esophagus is susceptible must be excluded. Some of the conditions to be considered in differential diagnosis are (1) carcinoma (2) tuberculous ulcerations (3) esophagitis



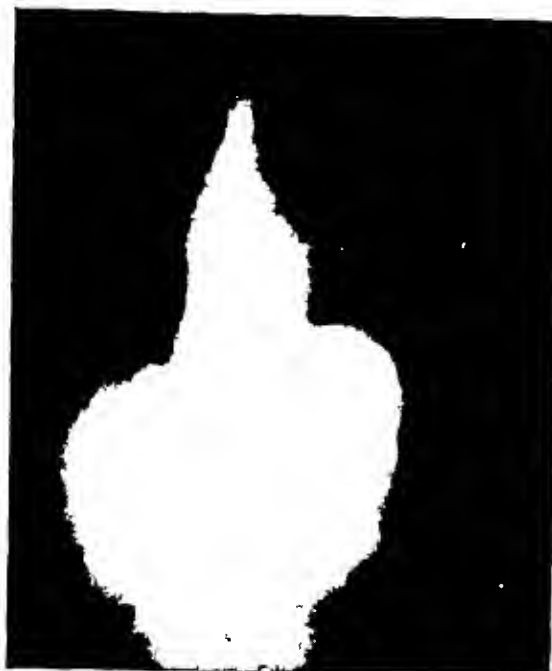


Fig 2-A Second examination



Fig 2-B Second examination

esophagus than in other portions of the alimentary tract. Lawrence states that syphilis of the esophagus is diagnosed as such in only one or two of every thousand cases in which lesions are present. Lukens and Ono found in the literature only 12 cases of tracheo-esophageal fistula attributable to syphilis. Another author found four syphilitic lesions of the esophagus in 350 consecutive cases of dysphagia, while still another writer claims that thousands of esophageal examinations may be made without finding a single case of syphilitic involvement. Myerson claims that from 95 to 98 per cent of all esophageal lesions in adults are carcinomas. Even though we admit that syphilis of the esophagus is occasionally unrecognized, it must still be considered a lesion, the diagnosis of which is seldom established.

The disease exhibits the same pathologic changes as those which occur in syphilis of other portions of the gastro-intestinal tract. Rarely is it in the congenital form, but it does occur. There is an esophagitis in the secondary stage often associated with mucous plaques and ulceration. We find the

gumma and the contractural sclerosis in the tertiary stage. Esophagitis occurs more often in the middle half, while gummas are usually in the upper or lower thirds. There may be induration and spasm. A gumma may ulcerate and rupture. Dilatation above the lesion is usually not a striking characteristic. Sclerosis and contracture may become pronounced, with almost complete stenosis. It is to be remembered that the appearance of the syphilitic ulcer may be largely influenced by secondary infection, and may present much the same picture as tuberculous or carcinomatous ulceration. Cases have also been reported in which the lesion is primarily outside the esophagus, but the esophagus is secondarily involved.

The symptomatology of this condition is similar in many respects to other stenosing lesions of the esophagus. There are relatively no early symptoms. There may be transitory periods of dysphagia in the stage of inflammation, or esophagitis followed by periods of freedom from any symptoms. A history of transitory attacks of mild dysphagia is of the greatest

was sent into the hospital for a second study about two months following his first x-ray examination. Very definite improvement is indicated (Fig 4). No esophagoscopic examination was made of this patient.

The two cases reported in this paper present the usual difficulties in diagnosis. The first case has a typical history of intermittent attacks of mild dysphagia over a period of months, followed by almost complete esophageal obstruction. Chemical or mechanical trauma has been ruled out and the Wassermann reaction was four plus. Malignancy and other types of lesions are rather well excluded by the x-ray and bronchoscopic examinations. The very definite improvement following dilatation and anti-syphilitic treatment is of great importance in confirming the diagnosis.

The diagnosis in the second case is a little more difficult in that the Wassermann was negative and there was no bronchoscopic examination. The history is of extreme importance, as previously stated, this man was supposed to have had an inoperable carcinoma of the head of the pancreas but made a complete recovery on anti-syphilitic treatment. Immediately after the first x-ray examination of the esophagus, the patient was again put on iodides and mercury. Improvement was rapid, so that the man was soon symptom-free. Subsequent x-ray examination confirms the clinical improvement. The amenability to

treatment seems to rather definitely establish the diagnosis in this case.

#### SUMMARY

The literature covering the subject of syphilis of the esophagus is briefly reviewed. Comment is made concerning the absence of any large number of case reports of this disease of the esophagus. The factors are discussed which are responsible for the difficulty in establishing and confirming the diagnosis. Two cases are reported in which the diagnosis is definitely verified.

#### CONCLUSIONS

- (1) Syphilis of the esophagus is rare, it is probably not as uncommon as is now supposed and many cases may go unrecognized.
- (2) It is difficult to diagnose.
- (3) Roentgen, esophagoscopic, serologic, and biopsy examinations are important.
- (4) Prognosis is important.
- (5) Treatment consists of the following anti-syphilitic, dilatation and local, dietetic.

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from chemical causes, (4) congenital stenosis, (5) cardiospasm, (6) neurologic conditions, (7) extra-esophageal and mediastinal lesions as aneurysms, tumors, and diverticula

Prognosis is good except in advanced stenosis, being of particular importance to the patient who may be thought to have esophageal carcinoma but in whom malignancy can be excluded. Extreme contractual sclerosis and stenosis are difficult to treat. The treatment in the early stages is the same as that for syphilis. In the late stages, successful treatment can be carried out only by the esophagoscopist, when stenosis is present due to sclerosis. Direct treatment of ulcerations by the esophagoscopist is considered important by some. Esophageal dilatation is necessary in stenosis. Diet must be regulated according to the ability of the patient to take food, it may be necessary to resort to other than oral methods of feeding in extreme cases. Some patients may benefit from gastrotomy and the value of this procedure should not be overlooked. No doubt each individual patient presents a problem distinct in itself as to the course of treatment.

Two cases of syphilis of the esophagus in which the diagnosis is rather well established, are presented. The first patient was a white male, 41 years of age, a plumber by trade, who gave a history of difficulty in swallowing for the past eight weeks, the dysphagia increasing in severity until finally he was able to swallow only liquids. He also admitted that for several months he had experienced transitory attacks of mild dysphagia. One month previous to our first examination, he was treated by an esophagoscopist who dilated his esophagus. This treatment was followed by a period of severe pain and inability to swallow. He refused further treatment and four weeks later presented himself for examination. He had lost 50 pounds in weight, being able to swallow only liquids, which he vomited within five minutes. There was no history of chemical or other form of trauma to cause a stenosis.

The physical examination was negative

except for the evident loss of weight. There was a mild secondary anemia, and the complement fixation reaction was four plus. X-ray examination showed a sclerosing lesion of the esophagus with almost complete stenosis (Figs 1-A and 1-B).

Esophagosopic examination was made and the following report given: "Narrowing at 24 inches from teeth, aperture central and  $\frac{1}{4}$  inch in diameter, not irregular, fibrous and tough, no ulcerations, dilated with filiform bougie. Diagnosis: esophageal stenosis, fibrotic in character, non-malignant, due to syphilis."

This patient was treated for a period of about nine months, the therapy consisting of repeated dilatation and systemic treatment. He was then sent in for a second roentgen study, the results of which are shown in Figures 2-A and 2-B. The man had regained his lost weight, was able to eat almost any type of food, and reported that he "felt fine."

The second case was that of a man nearly sixty years of age, sent in for esophageal x-ray examination because of difficulty in swallowing. The dysphagia had been noted at intervals for several weeks. There were no symptoms other than the dysphagia, neither was there any history of trauma, chemical or otherwise. X-ray study revealed a lesion of the esophagus (Fig 3). The history obtained from the physician in charge of this case is of particular importance. Eight years previous to the onset of the present trouble this patient developed a condition which was diagnosed as inoperable carcinoma of the head of the pancreas. He was advised against operative interference by several surgeons in different cities. His Wassermann was negative but nevertheless he was put on active anti-syphilitic treatment, chiefly iodides and mercury. His recovery was rapid and apparently complete cure was obtained. In view of this history, the patient was again treated with iodides and mercury. Improvement was noted shortly after treatment was begun and soon the patient was free from all symptoms, the dysphagia having entirely disappeared. He

was sent into the hospital for a second study about two months following his first x-ray examination. Very definite improvement is indicated (Fig 4). No esophagoscopic examination was made of this patient.

The two cases reported in this paper present the usual difficulties in diagnosis. The first case has a typical history of intermittent attacks of mild dysphagia over a period of months, followed by almost complete esophageal obstruction. Chemical or mechanical trauma has been ruled out and the Wassermann reaction was four plus. Malignancy and other types of lesions are rather well excluded by the x-ray and bronchoscopic examinations. The very definite improvement following dilatation and anti-syphilitic treatment is of great importance in confirming the diagnosis.

The diagnosis in the second case is a little more difficult in that the Wassermann was negative and there was no bronchoscopic examination. The history is of extreme importance, as previously stated, this man was supposed to have had an inoperable carcinoma of the head of the pancreas but made a complete recovery on anti-syphilitic treatment. Immediately after the first x-ray examination of the esophagus, the patient was again put on iodides and mercury. Improvement was rapid, so that the man was soon symptom-free. Subsequent x-ray examination confirms the clinical improvement. The amenability to

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# RADIORESISTANT EWING SARCOMAS OF BONE

By ALEXANDER BRUNSCHWIG, M D , F A C S , *Chicago*

From the Department of Surgery and Division of Roentgenology of the Department of Medicine the University of Chicago Clinics

It is frequently stated, sometimes with emphasis, that Ewing sarcomas of bone are quite radiosensitive because they usually show marked regression following irradiation. However, the use of the term "radiosensitive" to indicate mere regression following irradiation should not be encouraged, because such a usage confuses the true issue, which is complete destruction or prolonged growth restraint of malignant neoplasms by irradiation.

The large number of failures recorded for irradiation in the treatment of Ewing sarcoma are of limited significance in establishing its real value, because in the majority of cases the technics employed are now obsolete and the high mortality in Ewing sarcoma is the result of very early metastases. There are, indeed, few reports in which the neoplasm was biopsied, treated by irradiation alone, and, in the event of death, the irradiated primary tumor site examined histologically, with correlation of dosage and effects upon the tumor.

That Ewing sarcomas may be radiosensitive to the point of being destroyed or clinically controlled for long periods by irradiation alone is shown by the following reports of biopsied cases.

In addition to these cases, Bloodgood (3) cited two cases in which biopsy demonstrated the presence of Ewing sarcoma, one in the lower end of the fibula, and one in the shaft of the tibia in which local application of radium appears to have controlled the process locally for at least five and six years, respectively. Details of the amount of radium used and method of application were not given.

In contrast to the above cases, the following observations upon three patients followed in the University of Chicago Clinics are recorded. All of them died from widely disseminated metastases, and at necropsy, performed in the Department of Pathology of the University of Chicago, opportunity was afforded to study the irradiated primary tumor sites.

The physical factors in the irradiation (see below) were 200 kv, 25 ma, 50 cm FSD, 1 mm Cu plus 1 mm Al filtration, intensity, 38 to 42 r per minute.

In Cases II and III, a typical radio-epithelitis developed, the degree of which indicated that a maximum safe normal tissue tolerance dose had been given. In Case I, the skin was unusually resistant and accordingly more irradiation was given than in the other cases. Experience has

TABLE I

Author	Location of Tumor	Irradiation	Result
(1) Phemister (1931)	Rt clavicle Biopsy Ewing sarcoma	8 x ray treatments at 140 kv, 2- to 3-day intervals to total dose of $\frac{4}{7}$ erythema dose. Two months later two more treatments at 2-week intervals front and back over clavicle to total of 1 erythema dose.	Outer $\frac{1}{8}$ of clavicle and surrounding soft tissues removed four and one half months after biopsy. Microscopic sections showed no tumor. Patient alive and well 9 years and 8 months later.
(2) Stewart Harrison (1935)	Shaft of humerus with metastases (?) to scapula Biopsy of primary growth Ewing sarcoma	Protracted x-radiation ' 1300 r to anterior port and 1300 r to posterior port. Scapula also treated but dosage was not given.	Well three and one half years after treatment.
Same as (2)	Palatine bones Biopsy Ewing sarcoma	'Protracted x-radiation' details not given.	Well 2 years and 2 months after treatment.

shown that, once a neoplasm has survived amounts of irradiation similar to those given above and which produce a severe degree of epithelitis, there is practically no possibility of destroying it by subsequent irradiation given according to any one of several technics now in vogue. Hence, the cases of Ewing sarcoma cited above exhibited practically a maximum degree of radioresistance in terms of the technic of treatment employed (modified Coutard).

Radiosensitivity is one of the most complex questions in the cytobiology of malignant tumors. The factors concerned are little or not at all understood. For a long time it was held that radiosensitivity was directly proportional to anaplasia, but experience has shown many exceptions to this rule. There are no accurate methods of determining in advance the degree of radiosensitivity of any given neoplasm. This constitutes one of the major disadvantages of irradiation therapy for operable malignant neoplasms in which there is reasonable indication that metastases have not occurred.

From experience in irradiation of malignant tumors in general, it would seem that

radiosensitivity varies widely within most groups of tumors and even among any series that are histologically similar. The above studies indicate that among Ewing sarcomas there is a wide variation in radiosensitivity.

#### SUMMARY

Ewing sarcomas of bone exhibit a wide variation in radiosensitivity. Some may be destroyed or restrained for long periods by irradiation therapy alone.

Three cases are recorded in which the primary growths exhibited a maximum degree of radioresistance, as shown by histopathologic studies of the sites of the primary growths (obtained at necropsy) which had received maximum normal tissue tolerance doses of 200 kv x-radiation. The common current conception that all Ewing sarcomas of bone are "radiosensitive" is not justified.

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TABLE II

Cases	Primary Growth	Irradiation <sup>1</sup>	Clinical Course	Histologic Findings at Primary Tumor Site (Necropsy)
I Female aged 24 years (70 035)	Left ileum adjacent to sacro iliac articulation. Biopsy. Ewing sarcoma.	Irradiation delivered to ant and post pelvic ports. 1st series 5 100 r 2nd series 2 500 r 3rd series 6 380 r 4th series 2 100 r Total 16 080 r at intervals from Feb 1933, to April 1934.	Died 17 months after initial series of bronchopneumonia and widespread metastases.	Large masses of viable and proliferating tumor cells in bone and adjacent soft parts.
II Male aged 14 years (99 562)	Seventh dorsal vertebra with adjacent soft parts invasion. Biopsy. Ewing sarcoma.	Dosage of 5 000 r to 10 X 20 cm portal over spine. Irradiation delivered in 34 days.	Died 9 months after treatment. Disseminated metastases.	Masses of viable proliferating tumor cells in vertebra and surrounding muscles and ligaments.
III Male aged 19 years	Right scapula adjacent to glenoid. Biopsy. Ewing sarcoma.	A total dose of 6 320 r to ant and post portals 20 X 20 cm including scapula and shoulder joint. Irradiation delivered in 29 days.	Died twelve and one half months after treatment of extensive disseminated metastases.	Masses of viable tumor cells in bone at primary site and extending beneath suprascapular muscles.

<sup>1</sup> Dosage expressed in r units measured in air (Wulf ionization chamber).

## SMALL INTESTINE—INFLAMMATORY LESIONS AND ACCOMPANYING REACTIONS<sup>1</sup>

By LEWIS GREGORY COLE, M D, and ROBERT E POUND, M D, *New York City*

THE subject, "Inflammatory Lesions and Accompanying Reactions," is so extensive that we thought it best to approach the discussion under four main divisions. These are apt to overlap, and, under any circumstances, should be considered merely arbitrary divisions. Your attention will be directed to these similarities as they occur. The four main divisions are as follows:

- (A) Normal,
- (B) Interference with motor phenomena,
- (C) Products of inflammation,
- (D) Reactions in certain systemic diseases

As the radiologic technic employed in making gastro-intestinal examinations varies so widely in the hands of different physicians, it is necessary to present the normal, secured under the same technical conditions as the abnormal, in order to have an adequate control. Six ounces of a mixture of barium and water of a consistency comparable to thick cream is given on a fasting stomach. We insist upon overnight fasting as it is essential for the small intestine to be absolutely empty. The films are made at intervals which vary according to the type of case under consideration. Two very important technical factors are rapid screens and a maximum exposure time of a quarter of a second. A maximum exposure of a tenth of a second is preferable as the minor motor phenomena are so rapid that speed is demanded to secure detail. The normal rate of progress of the barium through the small intestine has a wide individual physiologic variation. Usually the head of the barium column enters the cecum within from two to four hours. The mucosal pattern and the general characteristics of the

two main divisions of the mesenteric small intestine are distinctive and fairly consistent. The division of the small intestine radiologically into six distinct groups has been described before this Society and appeared in 1927 in its Journal.<sup>2</sup> As we may later refer to an area being in a certain group, it is wise to review this division.

A schematic drawing to illustrate this division shows groups one, two, three, four, five, and six, and a slide demonstrating these groupings in a patient.<sup>3</sup> Group one, duodenum, group two, consists of coils in the upper left quadrant, group three, located in the lower left quadrant. The directions of the coils in these groups is transverse, that is, across the abdomen. Group four is located in the mid-line and the coils, finger-like in appearance, with the lumen running in a vertical direction, group five is located in the right lumbar region, group six is the terminal group of coils in the lower right quadrant, in the fourth and fifth groups you will note that the direction of the lumen is chiefly vertical, although it may be a mixture of both transverse and vertical. In observing these groups, the barium passed uninterruptedly through the various coils into the cecum. There was no delay in any particular group, and the characteristics of the various segments correspond to the normal.

*Interference with Motor Phenomena*—Lesions of an inflammatory character or those associated with some process which has an inflammatory reaction as a background, affect the motor characteristics of the small intestine through three different channels, namely, innervation, blood supply, and mechanics. Innervation is a term used in the broad sense and must not be

<sup>1</sup> Read before the Radiological Society of North America at the Twenty-first Annual Meeting at Detroit, Dec 2-6 1935

<sup>2</sup> The Anatomy of the Normal Small Intestine as Observed Roentgenographically. Russell W. Morse and Lewis Gregory Cole. RADIOLOGY, February 1927, 8, 149-153.

<sup>3</sup> Reference to slides shown at presentation of paper and not to illustrations in article.



Fig 1



Fig 2

Fig 1 Ileus Distention and arrangement of coils is practically identical with the mechanical obstruction

Fig 2 Enteritis Interference with normal motor phenomena—barium collects in segments similar to the reaction seen in the small intestine in an advanced type of ulcerative colitis

considered as indicating a specific nerve reaction alone or a neurologic lesion. In all cases of this group there is a disruption of normal peristaltic action or muscular tone or both. Since activity and tone of smooth muscle depends upon nerve stimuli, the lack of muscular activity evidenced in all cases of this group may be associated with changes in innervation. This may be either general or local. These changes in innervation may have their origin in the central nervous system but more likely in the sympathetic nervous system. They are probably due to a toxic effect or direct pressure on Auerbach and Meissner plexuses. An allergic phenomenon might be a better term if you can explain allergy. Under this heading we have grouped ileus, migraine enteritis and pancreatitis.

*Ileus (Fig 1)*—This is an atonic dilatation of the small intestinal coils with marked distention from gas and is generally considered paralytic. It may be associated with an inflammatory process in the peritoneal cavity or may be a reflex manifestation from

some more remote cause. The radiologic diagnosis of ileus depends upon the appearance of the gas-filled coils seen in plain films of the abdomen. The differentiation from a mechanical obstruction, particularly when the obstructive band is in the lower coils, is very difficult and at times impossible. The presence of gas outlining the colon is more often seen in ileus than in a low mechanical obstruction, this may be due to the fact that no gas passes through the obstructive point, or that repeated enemas and insertion of a rectal tube have emptied the colon prior to the time of radiologic investigation. In some cases it is extremely difficult to determine whether or not the distention is in the large or small intestine or both. In these cases it is wise to inject only a sufficient amount of enema solution to identify the colon.

*Enteritis (Fig 2)*—There are certain types of acute inflammatory reactions involving the small intestine and the lymphatic drainage area. The symptoms are frequently confused with an obstructive



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As the radiologic technic employed in making gastro-intestinal examinations varies so widely in the hands of different physicians, it is necessary to present the normal, secured under the same technical conditions as the abnormal, in order to have an adequate control. Six ounces of a mixture of barium and water of a consistency comparable to thick cream is given on a fasting stomach. We insist upon overnight fasting as it is essential for the small intestine to be absolutely empty. The films are made at intervals which vary according to the type of case under consideration. Two very important technical factors are rapid screens and a maximum exposure time of a quarter of a second. A maximum exposure of a tenth of a second is preferable as the minor motor phenomena are so rapid that speed is demanded to secure detail. The normal rate of progress of the barium through the small intestine has a wide individual physiologic variation. Usually the head of the barium column enters the cecum within from two to four hours. The mucosal pattern and the general characteristics of the

two main divisions of the mesenteric small intestine are distinctive and fairly consistent. The division of the small intestine radiologically into six distinct groups has been described before this Society and appeared in 1927 in its Journal.<sup>2</sup> As we may later refer to an area being in a certain group, it is wise to review this division.

A schematic drawing to illustrate this division shows groups one, two, three, four, five, and six, and a slide demonstrating these groupings in a patient.<sup>3</sup> Group one, duodenum, group two, consists of coils in the upper left quadrant, group three, located in the lower left quadrant. The directions of the coils in these groups is transverse, that is, across the abdomen. Group four is located in the mid-line and the coils, finger-like in appearance, with the lumen running in a vertical direction, group five is located in the right lumbar region, group six is the terminal group of coils in the lower right quadrant, in the fourth and fifth groups you will note that the direction of the lumen is chiefly vertical, although it may be a mixture of both transverse and vertical. In observing these groups, the barium passed uninterruptedly through the various coils into the cecum. There was no delay in any particular group, and the characteristics of the various segments correspond to the normal.

*Interference with Motor Phenomena*—Lesions of an inflammatory character or those associated with some process which has an inflammatory reaction as a background, affect the motor characteristics of the small intestine through three different channels, namely, innervation, blood supply, and mechanics. Innervation is a term used in the broad sense and must not be

<sup>2</sup> The Anatomy of the Normal Small Intestine as Observed Roentgenographically. Russell W. Morse and Lewis Gregory Cole. RADIOLOGY, February 1927, 8, 149-153.

<sup>3</sup> Reference to slides shown at presentation of paper and not to illustrations in article.

<sup>1</sup> Read before the Radiological Society of North America at the Twenty-first Annual Meeting at Detroit, Dec 2-6 1935.



Fig 5



Fig 6

Fig 5 Adhesions between adjacent coils of small intestine Note particularly the four loops in the mid line

Fig 6 Adhesions of the small intestine to an inflammatory mesenteric node—loops radiate from the node as a central point

*Acute Pancreatitis*—In acute pancreatitis one may have what appears to be an extension of the inflammatory process in the pancreas to adjacent loops of the small intestine, namely, the arc of the duodenum and the upper jejunum or second group of coils. This is evidenced by changes in the mucosal pattern, especially noticeable in the border of the duodenum adjacent to the pancreas and by variations in the diameter of the lumen which may be more or less than normal. In this film<sup>2</sup> the pancreatic outline is visible as it is outlined by the barium-filled stomach above and the duodenum below.

*Vascular Mesenteric Thrombosis*—In mesenteric thrombosis the radiologic findings in plain films are not conclusive. There is one observation which has been present more frequently than any other, namely, lack of gas. If a plain film of a patient with symptoms of abdominal pain and accompanying clinical manifestations of obstruction shows very little or no gas, the possibility of mesenteric thrombosis should be

immediately considered. The content of the lumen is usually fluid. When the loops are filled with a barium meal they show an atonic dilatation with no visible peristalsis. In this film made at five hours (Fig 4) the filled loops are shown containing only a small amount of gas. Peristaltic activity is practically absent. At twenty-four hours there has been but little forward progress, and at forty-eight hours the barium has not passed out of the small intestine.<sup>3</sup> The amount of gas is increasing with the toxicity and the paralysis is more evident. We might say in passing that the diagnosis was made on the five-hour examination, but the patient refused operation by any other than her own personal surgeon. He was away and out of reach for seventy-two hours. The diagnosis was confirmed.

*Mechanical*—The mechanical obstructions secondary to adhesions, which constrict the lumen by producing strictures, angulations or rotations (volvulus), have been described, and the findings are familiar to all roentgenologists. The festooning



Fig 3

Fig 3 Migraine Dilatation of small intestine—diminution in major motor phenomena



Fig 4

Fig 4 Mesenteric thrombosis Five hour film absence of peristalsis—stagnation of the barium in a few small intestinal loops

lesion of a mechanical type or a peritonitis, *i e*, nausea, vomiting, abdominal pain, tenderness, fever, and absence of the usual diarrhea of enteritis. Roentgenographically, the findings show a very definite interference with the motor phenomena evidenced by a marked diminution in activity, a slight atony, or dilatation of the filled coils and a delay proximal to the area of greatest involvement. The amount of intestinal gas is not markedly increased, and the barium has a tendency to stagnate in segments. The plain film in such a case shows no evidence of obstruction or gas in the small intestine.<sup>3</sup> A considerable amount of gas is collected in the right half of the colon. At two hours following a barium meal the head of the barium column is in the second group of coils. There is a slight atonic dilatation of the filled coils. At four hours the forward progress of the barium is extremely slow, and the collection of the barium in the dilated coils is shown. At six hours all the barium is collected in a few coils in the left side of the abdomen. The disruption of

normal motor phenomena is quite evident. The delay is proximal to the lower coils, and yet there is no evidence of mechanical obstruction. In this case a diagnosis of intestinal obstruction, unknown in origin, not mechanical, was made. At operation there was an acute reaction throughout the wall of the small intestine, greatest in the ileum. A moderate amount of peritoneal fluid was present and extensive lymphadenitis of the mesenteric glands. There were no bands and no mechanical obstruction. Fever continued for two weeks, then returned to normal with disappearance of clinical manifestations. Typhoid was considered after surgical visualization, but all cultures and repeated Widal's were negative.

*Migraine* (Fig 3)—The abnormal dilatation of the small intestine, with a conspicuous absence of the major and minor motor phenomena leaving only the plica circularis as an anatomic finding, was associated with this case of migraine. Did the reaction in the small intestine produce the migraine or *vice versa*?



Fig 5



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Fig 6 Adhesions of the small intestine to an inflammatory mesenteric node—loops radiate from the node as a central point

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Fig 7



Fig 8

Fig 7 Tuberculosis of the lower ileum and cecum Continuous type—illustrates inflammatory changes in the wall

Fig 8 Tuberculosis Skip type—numerous inflammatory lesions with uninvolved segments between

of dilated gas-filled small intestinal coils across the abdomen in the stepladder formation is quite characteristic and denotes an obstructive or partially obstructive lesion. The difficulty lies in determining whether it is actually mechanical or whether it is one of the types previously discussed. A differential diagnosis from plain films is tricky, the history may confuse instead of clarifying the etiologic factor. The lesser degrees of manifestation of these mechanical deformities are produced by the same etiologic factors, and the symptoms depend chiefly upon the degree of obstruction to the lumen. These deformities result from adhesions between the adjacent walls of coils of small intestine (Fig 5), between the serosa of the small intestine and some other viscus, or around the lymph nodes (Fig 6). The involved loops may be only moderately dilated, if at all, with the mucosal pattern still present or so dilated that it is lost, and the individual loop resembles the colon. The correlation of the clinical symptoms with minor deform-

ities is extremely puzzling and often problematical.

*Products of Inflammation*—We have divided these into two main groups, those occurring outside the wall, such as adhesions, and those inflammatory reactions primarily inside of the wall, such as the lesions produced by regional inflammation and tuberculosis. The extrinsic lesions (adhesions) merge with the mechanical interference with motor phenomena, shown previously, and need not be repeated. The intrinsic ones, inside the wall, are best demonstrated by the alteration in the structure of the wall and lumen secondary to tuberculosis. In these lesions the distal portions of the ileum seem to be the site of preference. There are two main types of involvement, the isolated or continuous lesion (Fig 7), and the so-called skip lesion (Fig 8). In the continuous type of lesion, the lumen is narrowed, and the walls are irregularly thickened. The barium passes through the altered lumen in an irregular, narrow stream. The lumen margins are



Fig 9



Fig 10

Fig 9 Small intestine in deficiency states—changes in the normal mucosal pattern particularly evident in the transverse loop across the fourth lumbar vertebra

Fig 10 Small intestine reaction in deficiency states. Collection of barium in segments of ileum resembling a bunch of bolognas. Loop in lower left quadrant shows irregularities in contour

serrated in appearance, corresponding to the irregularities produced by the stage to which the disease has progressed. The speed with which the barium passes through the involved area depends upon the amount of local or current irritability. The adjacent normal coils appear to be displaced from the involved area, due to the thickening of the walls of the diseased portion. In this type the lesion is usually single and the area of involvement continuous. The skip lesion usually involves shorter segments, and the irregularities of the lumen again depend upon the stage of progress of the inflammatory reaction. Between the areas of local contractures there may be present arcs of compensatory dilatation or relatively normal appearing lumen. These lesions may entirely encircle the lumen or may be limited to one side as shown by the absence of normal markings on the mesenteric border, and the presence of exaggerated markings on the anti-mesenteric border. In our own experience with these two types of involvement obstruc-

tion has been an infrequent complication.

*Regional Ileitis (that is, Non-tuberculous Ileitis)*—So far as we know we have never had an authentic case which has been proven by surgical procedure or autopsy. That it does occur we do not question, but in our own practice it is undeniably rare, either because we have failed to recognize obvious cases or there have not been any.

*Reactions in Systemic Diseases with Particular Reference to the Deficiency State (Figs 9, 10, and 11)*—By "deficiency states" we refer to those conditions associated with partial deprivation of certain vitamins, of protein, and of important organic elements. Our experience lies chiefly in the reactions occurring in sprue and in the lesion generally referred to as "ulcerative colitis." In a large group of these cases in which the obvious symptomatology is referred to the colon, it was decided it might be of interest to observe what was occurring in the small intestine. It was thought that there might be some change in the rapidity of the motor

progress, which because of its speed might interfere with normal absorption and thus influence the state of obvious deficiency which accompanies the severe stages of these diseases. A very definite reaction in the small intestine was found constant in cases of the severe type. Delayed forward progress instead of increased speed was invariably present. Changes in the appearance of the mucosal markings are found from the duodenum to the cecum. The normal markings are wider—that is, thickened—and frequently bizarre in appearance. The motor phenomena are disrupted. It is perhaps much simpler to demonstrate a case of this type in which all variations in mucosal pattern and deranged motor phenomena are visible.<sup>2</sup> Let us say that the patient has been suffering from a severe infection of ulcerative colitis for several years. At the present time the number of stools varies from twenty to thirty *per diem*. The physiologic condition is that of an extreme deficiency state, but he is hospitalized for study rather than from necessity. A chronological study of the changes occurring in the small intestine can be demonstrated. At five minutes the second group of coils is filled and normal mucosal markings are exaggerated. At thirty minutes the head of the barium column has progressed slightly. The thickening of the circular folds of the duodenum is evident. Observe the mucosal changes in two of the lower filled loops. Note particularly the lowest loop, as your attention will be directed to this area in the four-hour film. At sixty minutes note irregular filling of various coils with exaggerated mucosal markings. At one and a half hours slow forward progress, at two hours the same bizarre appearance of the mucosal pattern, at two and a half hours most of the barium has collected in two segments in the lower left quadrant in the third group of coils. Gastric peristalsis has lessened in the last two films. At three hours no further forward progress has been made, note the isolated coil to the left of the umbilicus. At four hours gastric evacuation has again started (Fig 10). The filled coils

in the right side of the abdomen are grouped in bologna-like fashion. The diameter varies. No barium has apparently entered the cecum. The deformed loop in the lower left quadrant is the same as in the thirty-minute film. Magnification of this particular loop reveals the extent and constancy of the changes to a better degree. At six hours barium has entered the colon. The filled small intestinal loops are grouped throughout the abdomen in isolated segments (Fig 11). At seven hours the stomach is practically empty. The diameter of the lumen of the small intestine varies throughout, with special dilatation in the lower left quadrant. The barium seems to move by segments or groups of coils.

For comparative study subsequent series are made at corresponding intervals and one is able to follow the progression or resolution of these abnormal small intestinal manifestations during the course of the disease. It would seem that as improvement occurs, or if the disease progresses, the manifestations in the small intestine should correspond. This is the rule with certain modifications. There frequently occurs a lag in either direction, that is, the clinical course may improve considerably but the small intestinal changes respond more slowly. On the other hand, the small intestinal changes may increase while the clinical course is apparently definitely improving. If this occurs, trouble for the patient is not far away, and it is a distinct warning that some complication is in the offing or a relapse is imminent. In several apparently favorably progressing cases we have had distinctly unfavorable changes in the small intestinal manifestations by which we were able to predict a relapse by means of comparative studies.

To demonstrate the improvement in the favorable progress of the disease, we shall compare the two series on the same patient made during treatment.<sup>3</sup> Bear in mind that the first series was made during the severe stage of the disease. The second series was made during a period of definite improvement in the clinical mani-

festations One-hour film—first series—barium which has been evacuated from the stomach is collected in several groups of coils in the mid-line, irregular mucosal markings, lack of barium in the coils proximal and distal to filled coils One-hour film—second series—greater evacuation of stomach, continuity of barium stream, fairly normal mucosal markings Two and one-half hour film—first series—very little, if any, progress in the barium grouped in the coils seen in the one-hour film, gastric evacuation is beginning again as shown by barium in the duodenum, widened markings of duodenum Two and one-half hour film—second series—gastric evacuation complete, barium progressing toward the cecum Four-hour film—first series—puddling of all barium which has been evacuated in a single segment in the mid-line, no barium proximal or distal to filled segment, gastric peristalsis absent Four-hour film—second series—further progress of barium, head of column in the region of the cecum, the appearance of filled coils fairly normal At six and a half hours—first series—gastric evacuation again commencing, barium has moved out of the isolated segment into few coils distal to that area but has not entered the terminal coils or the cecum Six and one-half hour film—second series—most of barium has entered the cecum, only a small amount remains in the terminal ileum, normal forward progress

Thus far we have dealt with the gross appearance of the coils in their entirety One of the reasons, and, in our own opinion, the chief reason that small intestinal lesions have not attracted greater attention, is because of the relatively small size of the lumen and mucosal markings of a local area as compared to the numerous coils and extreme length of the entire viscus Slight variation in the normal contour and markings would, therefore, be more likely to escape detection How many of you have recognized the presence and location of a very definite abnormal loop shown on this slide? (Fig 9) The lesion is clearly seen in the transverse loop directly in the mid-line and on a level with the fourth lumbar



Fig 11 Small intestine in deficiency states Irregularities in contour and variations in diameter of the lumen, diversity of size of loops dependent upon the degree of filling, peristaltic action does not result in a continuous flow of barium through the small intestine

vertebra The absence of mucosal markings along the mesenteric border with exaggeration of the markings on the anti-mesenteric border is clearly visible if one's attention is directed to this region However, if the local region is magnified four or five times, the changes become as evident as the deformity of the stomach in an inoperable carcinoma Magnifications of local areas which are involved or under suspicion of involvement will usually demonstrate the deformity to a startling degree, and is comparable to the use of a magnifying glass in the search for fissure fractures The deformities of the cap were present from the beginning of radiological exploration of the gastro-intestinal tract, yet they escaped detection and pathologic correlation for years At the present time the clover-leaf deformity of the cap is as symbolic of a post-pyloric ulcer as the red light is of danger Is it not merely a question of properly directed observation? There was once a man (W H S) who could never find a four-leaf clover This upset his equanimity to no small degree, as he began to think himself a bit sluggish mentally or



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addicted to extremely poor luck. So he requested from one of his friends who was always finding these lucky four-leaf clovers a handful of these prizes he could not himself find. He then gathered a box of ordinary clover leaves and mixed his handful of four-leaf ones in with these. He spent

hours picking the four-leaf ones out of the mass until after a relatively short while he could separate them out with the greatest of ease. His eyes are now trained so that he can find them readily in his own clover patch. Is this not a matter of properly directed observation?

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# X-RAY DIFFRACTION STUDIES OF TENDON AND INTESTINAL WALL COLLAGEN

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Department of Chemistry, University of Illinois

THE x-ray diffraction patterns obtained from the fibrous proteins usually are characteristic fiber patterns but differ widely from each other in degree of perfection, depending upon the nature and relative proportions of the different amino acids of which the protein is built up. In the case of silk fibroin and keratin, a satisfactory solution of the crystal structure has been worked out from the data of the x-ray diffraction pattern. On the other hand, collagen or gelatin, being made up of some fifteen or more different amino acids of widely differing functional groups and molecular weights, previously have not given patterns with sufficient orientation and number of interferences to lend themselves readily to accurate analysis, and as a result no entirely satisfactory solution of structures has been developed. The diffraction pattern of ordinary untreated collagen or gelatin indicates the existence of long chain-like molecules which are rather easily oriented but which lack sufficient organization of their component parts of amino acid residues to produce a well-defined crystal lattice. Indeed, the existence of a halo, which shows indication of partial orientation, superimposed upon a fairly sharp interference pattern actually indicates a structure which truly may be called "pseudo-crystalline." The explanation of the lack of structural organization found in this protein is generally considered to be due to mutual attraction of the large number of polar groups which naturally must exist in such a structure. In a substance whose make-up is as complex as that of collagen in which highly polar groups must be distributed at unequal intervals in both the side chains and along the main

chains, the structural design cannot be expected to conform to any definite geometric pattern but, instead, will be fashioned more likely according to the chemical nature of this material, occurring naturally in so many forms, and will yield readily to the unbalanced forces, resulting in a highly distorted structure. The interpretations of the diffraction pattern of this protein usually have been given with an effort to conform to conclusions already deduced from the mass of carefully compiled chemical data and as a result often were in direct contradiction to what few facts were actually indicated.

The practical, as well as the theoretical and biological, significance of new information on the crystal structure of collagen is readily seen from its wide use in the manufacture of leather, gelatin, glue, surgical catgut, musical instrument strings, etc. It is the purpose of this paper to describe new results of the application of x-ray diffraction technique to the study of this protein, which should throw more light upon the nature of its structure.

## X-RAY SPECTRA OF UNMODIFIED COLLAGEN AND GELATIN<sup>1</sup>

Although x-ray investigations of the structure of collagen and gelatin have not been so extensive in recent years, nevertheless a considerable amount of work has been done. Herzog and Jancke (15), in 1926, first attempted to assign the crystal system and dimensions of the unit cell. From their data they suggested a tetragonal unit cell of the following dimensions  $a=b=23.40 \text{ \AA}$ ,  $c=29.06$  (fiber axis). However, from a description of the pattern obtained nothing more than an ambiguous interpretation could be made from their results. Recent authors have made scarcely any attempt at the solution of the crystal

<sup>1</sup> Based on portion of thesis submitted by John A. Schaad for Ph.D. degree, University of Illinois, June 1936.

Bauer and Black, *ibid.* 1933-1935.

structure. However, from the usual diffraction pattern of unmodified collagen, poor though it is, several important deductions have been made. The usual pattern obtained at the ordinary sample-to-plate distance of 5 cm, employing Cu K $\alpha$  radi-

The innermost equatorial arc is given by a plane whose "d" value varies from 10.4 up to about 17.0 Å, depending upon the amount of water held by the protein. This spacing is assumed to represent the perpendicular distance between chains in the pro-



Fig 1



Fig 2



Fig 3

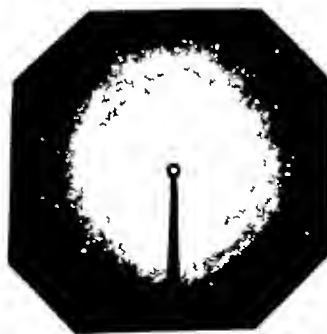


Fig 4

- Fig 1 X ray diagram of unmodified tendon collagen (3 cm )  
 Fig 2 Sodium hydroxide-collagen addition compound (3 cm )  
 Fig 3 Sodium hydroxide-collagen addition compound after deswelling in a solution at the isoelectric point showing reversibility (3 cm )  
 Fig 4 Sodium hydroxide gelatin addition compound (3 cm )

tion, consists of but few relatively sharp interferences, together with a broad amorphous halo and is essentially the same for both collagen and gelatin. A typical pattern of a well oriented collagen sample is shown in Figure 1. A brief description of the significant features of such a pattern will follow.

tein grid (1, 14) and may be determined to some extent by the length of the side chains. Due to the variability of this "d" value, a lateral covalent bond as postulated for keratin (5, 7) is hardly possible. The most probable structure is a salt-like linkage, as, for example, between the basic

residue of arginine and the acidic residue of glutamic acid (21, 22)

The characteristic halo corresponding to a spacing of about 4.5 to 6.1 Å U, apparently common to all fibrous proteins, is assumed by Astbury (1, 2, 3) and others to represent the thickness of the protein chain or grid. In this lateral direction the chains are assumed to be held together by secondary valence forces only (3, 21, 25).

A rather intense meridional arc of about 2.84 Å U is always found, which never approaches a circular spot even in the most perfectly oriented specimens. Although much shorter than the theoretical, Astbury and others (1, 4, 14, 17) have assumed this spacing to be the length of one amino acid residue. Some investigators have described this plane as being perpendicular to the fiber axis (diatropic) (12), whereas others have realized that it can be only a pseudo-diatropic plane (17) and therefore the real residue length must be somewhat longer. Heringa and Kolkmeier (13) believed this plane to be tilted at an angle of 86° or 87° instead of 90° to the fiber axis. Others have described the long arc length as being due to a sort of a spiral or folded (20) arrangement of the chains or micelles.

Four symmetrically located spots given by a diagonal plane form a distinct layer line corresponding to a fiber identity period of about 9.75 Å U (14, 25), or approximately three times the length of a normal amino acid residue. Astbury, in explaining this identity period, preferred to use the value of  $3 \times 2.8$  or about 8.4 Å U (1, 3) instead of the value of approximately 9.75 Å U as obtained by other investigators (12, 14, 15, 17, 24, 25, 26). Katz (18) noted this discrepancy but offered no explanation for it.

To account for the partially oriented halo shown in collagen fibers and stretched gelatin, Gerngross, Hermann, and Abitz (12) suggested that the protein chains forming a micelle were not of uniform length and that the apparent amorphous component represented the frayed ends of these chains. These same authors later suggested the possibility that some amino

acids may form the so-called "fringed ends" and others, of a different nature, the body of the main chain (14). Other investigators (17, 25) have held similar views.

Gelatin, being the hydrolysis product of collagen, is generally considered to be made up of fragments of the partially broken down collagen micelles or crystallites. The diffraction patterns of collagen and gelatin have been compared by several investigators but with the exception of a recent work published by Clark, Parker, Schaad, and Warren (9) using special technique, no significant differences have been noted. In this work was reported the presence in collagen (surgical catgut) *but not in gelatin* of a very long meridional spacing of about 440 Å U, and an equatorial spacing of 48.0 Å U. In a later publication Wyckoff, Corey, and Biscoe (27), using tendon collagen, obtained a value of 330 Å U for the long meridional spacing but reported no long equatorial spacing at all.

Thus it can be seen that our knowledge of the crystal structure of this protein obtained from patterns of the unmodified material is as yet very fragmentary and not at all satisfactory. This fact suggests the thorough study of the structure of the derivatives or addition compounds of collagen or gelatin as a possible source of additional information on the structure of the original material.

#### ALKALI ADDITION COMPOUNDS OF COLLAGEN

*Action of Sodium Hydroxide upon Collagen*—During the investigation of the swelling action of solutions of strong alkalis upon tendon collagen it was found that an entirely new diffraction pattern was produced with alkalis of a certain minimum concentration. Collagen fibers, upon treatment with dilute sodium hydroxide, undergo strong lateral swelling with a relatively small decrease in length, the effect increasing as the alkali concentration is increased. The new compound formation as revealed by the fiber pattern was found to appear after a 24-hour swelling period in 0.2 N sodium hydroxide. However, at this concentration only a partial transforma-

tion was affected and it was found necessary to increase the value up to about 0.4 N in order to obtain a clear-cut pattern. Concentrations above 0.5 N were found to be unsatisfactory as decomposition was too rapid.

That the product of the reaction between a strong alkali and collagen may be called an addition compound seems to be justified by the similar reaction of concentrated sodium hydroxide with cellulose and chitin, two somewhat analogously constructed compounds. Sodium hydroxide of mercerizing strength produces a very definite change in the crystal structure of cellulose, in which case the change appears to be definitely in the direction of a more stable structure as all attempts to revert to the original have not been successful (8, 16). In the case of chitin, also, a very definite modification is obtained, but it apparently is reversible (10). In the present case of collagen the process appears to be a reversible one, since subsequent treatment in a solution whose  $pH$  is approximately that of the isoelectric point of the protein causes a rapid subsiding of the swelling to about the same degree as that shown in distilled water.

*Preparation of Sample for X-ray Analysis*—The sample used was selected from the tendon of Achilles of an ox. After 15 minutes extraction with boiling ether it was dried and placed in a 0.4 N NaOH solution at room temperature. Although swelling appeared to have reached a maximum after a period of three hours, the sample was allowed to remain in the solution for approximately twenty-four hours to insure rather complete swelling. At the end of this period the fibers had swollen to such an extent that they were quite transparent. Then, without removal by washing of the alkali, the fiber bundle was securely clamped at either end with steel clips and hung up. A 1.5 kg weight was suspended from the sample and under these conditions several hours were allowed for drying. Although not necessary in the formation of the new structure, a certain amount of tension during drying is very desirable since a

much sharper fiber pattern is obtained. The sample then was x-rayed in the usual manner with filtered copper  $K\alpha$ -radiation at a film distance of 3 centimeters. The diffraction pattern is shown in Figure 2.

*Crystal Structure of the Sodium Hydroxide-collagen Addition Compound*—The reproduction clearly reveals a very well developed fiber pattern showing a degree of perfection exceeding by far that of any other modification of collagen yet reported. By the usual methods of analysis of x-ray fiber patterns the solution of the crystal structure is readily obtained. From a visual observation of the pattern there appears to be three layer lines shown by the addition compound. The value of the identity period along the vertical crystallographic axis shown by these lines as calculated from the equation

$$C = \frac{n\lambda}{\sin 2\theta \cos \psi}$$

(11) was found to be  $6.50 \text{ \AA U}$ . Since the reproduction shows that there is superimposed upon the pattern of the addition compound, that of the original structure in which the fiber identity period along the vertical axis is  $9.75 \text{ \AA U}$ , exactly three halves times the value of that of the addition compound, the possibility at once suggests itself that the reaction may be complete and that both periods and patterns belong to the same crystal structure. If this were true then the common identity period along this axis would necessarily be  $19.50 \text{ \AA U}$ . However, as is shown later in the discussion of the addition compound formed with potassium hydroxide, the  $9.75 \text{ \AA U}$  period belongs only to the unchanged material and the three halves relationship between it and that of the addition compound is probably only coincidental. Furthermore, for an alkali-swollen fiber in which great care has been taken to insure a nearly complete reaction by occasional kneading of the plumped fiber, the  $9.75 \text{ \AA U}$  identity period of the original material is found to be very weak.

From the measured interferences of the pattern the structure was found to belong

to the orthorhombic system with the following unit cell dimensions  $a = 5.32 \text{ \AA U}$ ,  $b$  (fiber axis)  $= 6.50 \text{ \AA U}$ ,  $c = 11.90 \text{ \AA U}$ . In Table I are given the data for all the interferences indexed. The number of the layer line is given by the Roman numeral and the position of the spot on the layer line beginning at zero for the center and going out is given by the subscript. All interferences falling on the equatorial line are designated by the letter A. The intensity of each spot was estimated and is designated by the following notation: s = strong, vs = very strong, m = medium, w = weak, vw = very weak.

A comparison of the calculated and measured values of "d" shows excellent agreement between the two. Furthermore, the "row lines" of a pattern indexed from the values of Table I prove beyond any doubt that the crystal system and unit cell dimensions are correct. Taking the  $b$  length of the cell to be  $6.50 \text{ \AA U}$ , which is approximately the length of two acid residues, the unit cell then is found to contain two amino acid residues.

A density determination of the air-dried, sodium hydroxide-treated sample gave a value of  $1.372 \text{ g/cc}$ . From this value, and with the assumption of two amino acid residues per unit cell, the mean molecular weight of the acid residue of the alkali addition compound was calculated as follows:  $\text{Mol wt} = \text{volume} \times \text{density} / \text{absolute mass of hydrogen atom} \times \text{number of molecules per unit cell} =$

$$\frac{(6.50 \times 10^{-8} \times 5.32 \times 10^{-8} \times 11.9 \times 10^{-8}) \times 1.372}{1.65 \times 10^{-24} \times 2} = 170$$

The value of 170 is very large compared with the value of 96 as calculated for the mean residue weight of the amino acids found in gelatin (6). However, this discrepancy is accounted for when one considers the fact that not only are the charged centers of the protein highly hydrated but a considerable amount of sodium hydroxide also must be present.

In order to obtain a rough estimate of the amount of alkali taken up by the protein lattice in the formation of the addition

TABLE I

Interference	Intensity	d'	d''	Indices
		Measured Å U	Calculated Å U	
A <sub>1</sub>	vs	11.80	11.89	001
A	m	5.32	5.32	100
A <sub>2</sub>	w	2.98	2.98	004
A <sub>4</sub>	vw	2.68	2.66	200
A <sub>5</sub>	vw	2.38	2.38	005
A <sub>6</sub>	vw	1.98	1.98	008
A <sub>7</sub>	vw	1.77	1.77	300
I <sub>1</sub>	m	2.68	2.70	014
I <sub>1</sub>	m	2.48	2.46	210
I <sub>3</sub>	s	2.38	2.41	114
I <sub>4</sub>	m	2.23	2.24	015
I <sub>6</sub>	s	2.10	2.09	213
I <sub>6</sub>	w	1.89	1.90	016
II <sub>1</sub>	vs	2.78	2.78	120
II <sub>2</sub>	m	2.68	2.70	121
II <sub>3</sub>	m	2.47	2.51	122
II <sub>4</sub>	m	2.19	2.19	024
II <sub>5</sub>	m	2.08	2.06	220
II <sub>6</sub>	m	2.01	2.03	124
II <sub>7</sub>	m	1.92	1.92	025
III <sub>1</sub>	w	1.87	1.90	132
III <sub>2</sub>	m	1.73	1.75	034
III <sub>3</sub>	m	1.67	1.68	230
III <sub>4</sub>	m	1.64	1.66	134
III <sub>5</sub>	m	1.60	1.60	035

compound, an ox tendon fiber weighing about two grams was allowed to swell in a measured volume of a standard solution of sodium hydroxide. The flask containing the solution and the sample was sealed tightly during the swelling period to prevent the absorption of carbon dioxide. At the end of two days the fiber was removed from the solution and the amount of alkali taken up was calculated from the volume and concentration of the solution remaining. The following data show the weight in grams of sodium hydroxide taken up by 100 grams of collagen at two different concentrations.

(The weight of collagen is based upon the weight after drying at  $110^\circ \text{C}$  to constant weight.)

Concentration of NaOH	g. of NaOH taken up by 100 g. of collagen
0.955 N	9.13
4.680 N	51.30

Assuming the mean molecular weight of the amino acid residue to be around 100, then at the lower concentration the data show that approximately one molecule of alkali is taken up for every four or five



amino acid residues. It is at this concentration that the pattern of the addition compound first appears. At the higher concentration it is seen that slightly more than one molecule of alkali is taken up for each amino acid residue. Inasmuch as a certain amount of alkali necessarily must be held by capillary attraction in the fiber bundle, the highest combination ratio between the alkali and the amino acid residue is probably very nearly 1:1. In view of these results the value of 170 for the mean molecular weight per acid residue under these conditions is not at all unreasonable.

If the atomic radii of the carbon and nitrogen atoms are taken to be 0.77 and 0.70 Å U, respectively, and the interbond angle of the aliphatic carbon atom to be  $109^{\circ}28'$  (actually it is probably somewhat less in aliphatic chain compounds) and that of the N atom slightly less, the theoretical length of each normal amino acid residue should be about 3.5 Å U. In the case of silk fibroin this value is almost realized, whereas in  $\beta$ -keratin it is found to be somewhat less, about 3.4 Å U, presumably because of the distorting effect of heavy side chains. Astbury, in describing the spectrum of unmodified collagen, has assumed the interplanar spacing value of 2.8 Å U to be its amino acid residue length (1). Since this value is far shorter than the theoretical and does not approximate any submultiple value of the true identity period of 9.75 Å U, this interference must be explained in some other manner. The assumption of two amino acid residues per unit cell length of 6.50 Å U in the sodium hydroxide addition compound of collagen gives a single residue length of only 3.25 Å U. However, this value is well within reason when it is considered that approximately 30 per cent of the total amino acids in collagen are either proline or hydroxyproline, the residues of which due to the five membered ring structure in each, must be at least 0.25 Å U shorter than the length of a normal fully extended residue. Furthermore, the double residue length is in perfect harmony with the accepted theory of the peptide chain structure in which there is assumed to

be a twofold screw axis of symmetry of both the carbonyl and imide groups. In the construction of models or diagrams of fibrous protein structures the carbonyl and imide groups of protein chains of two adjacent grids are usually located opposite each other. Although this is a natural deduction from the idea of mutual attraction between the two groups, the x-ray spectrum of the alkali addition compound gives no indication that the unit cell should have a depth of two acid residues.

The diffraction data are not yet sufficiently complete to undertake the establishment of the proper space group, the chief difficulty lying in the fact that low orders of many of the most important interplanar spacings are obscured by the halo of the pattern of the original material which seems always to persist.

Perhaps the most important question now to be answered concerns the exact location and mode of combination of the alkali in the lattice of the collagen crystallite. The appearance of additional interferences upon swelling in sodium hydroxide followed by drying may be due to a neutralization of certain polar forces within the lattice, thus allowing the structural units of the protein to assume a more definite geometrical arrangement, the alkali serving only to support the diffracting units in their proper places and itself not directly contributing to the diffraction. However, the large amount of sodium hydroxide taken up, approximately one molecule of sodium hydroxide per amino acid residue, strongly suggests that the alkali takes up a very definite position within the protein crystal lattice and itself may contribute most to the diffraction. From a consideration of a single amino acid residue, it is theoretically possible that a carbonyl group adjoining an imide group may give rise to an acidic residue through enolization and in this manner combine with a molecule of alkali. The alternative is that the alkali is held merely by co-ordination at some position within each amino acid residue. At any rate, the alkali appears to be bound quite firmly since a fiber swollen in such a manner will

dry readily in the ordinary atmosphere without the formation of any appreciable

*Reversibility of the Sodium Hydroxide-collagen Addition Compound*—The peculiar

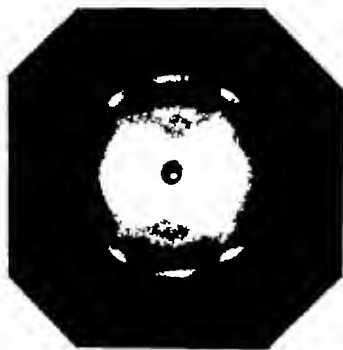


Fig 5

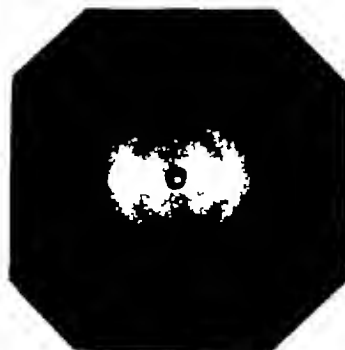


Fig 6



Fig 7



Fig 8

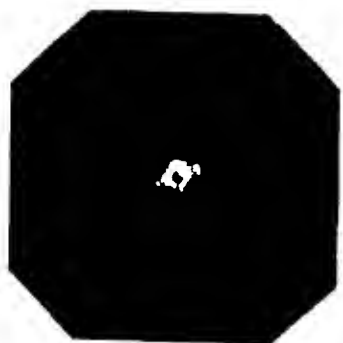


Fig 9



Fig 10

- Fig 5 Potassium hydroxide-collagen addition compound (3 cm )  
 Fig 6 Lithium hydroxide-collagen addition compound (3 cm )  
 Fig 7 Catgut suture Taken in vacuum (10 cm )  
 Fig 8 Same sample as shown in Figure 7 Taken in air (10 cm )  
 Fig 9 Untreated tendon collagen showing various orders of long meridional spacing (20.5 cm )  
 Fig 10 Sodium hydroxide-collagen addition compound showing long meridional spacing (20.5 cm )

amount of sodium carbonate as revealed by the x-ray diagram

structural effect produced in collagen by swelling in sodium hydroxide is easily re-

versible When a fiber swollen in the usual manner in 0.5 N alkali is placed in a buffered solution whose pH is approximately the same as the isoelectric point of the protein, namely, 4.78, a very rapid subsiding of the swelling takes place and after a period of a few hours the swelling amounts to little more than that shown by a fiber swollen in ordinary distilled water After drying under tension in the usual manner, the x-ray pattern is seen to be exactly the same as that given by unmodified collagen The diffraction pattern is shown in Figure 3

*Action of Sodium Hydroxide upon Gelatin*—Ribbons of well-oriented gelatin upon swelling in 0.5 N sodium hydroxide under similar conditions failed to show any such well-oriented structures in their x-ray diagrams (Fig. 4) Upon the patterns faint but sharp arcs were seen which indicated the same addition compound as that shown with collagen The gelatin strips were dried under a small amount of tension which evidently was sufficient to line up the crystal particles or micelles themselves as shown by the well-defined 001 interference However, it seems that the tension which can be applied to a swollen gelatin fiber is not sufficient to hold the individual protein chains in alignment This phenomenon seems to be strong evidence in support of the theory that in collagen the micelles are linked together across their ends by some sort of binding force which gives the fibers their tensile strength

*Addition Compound with Potassium Hydroxide*—A similar compound is formed by the action of potassium hydroxide upon collagen In this case the resulting crystal structure of the compound is much different from that formed with sodium hydroxide due perhaps to the difference in size of the two alkali metal ions In Figure 5 is shown the x-ray pattern of the potassium hydroxide addition compound Since there are but relatively few interferences on the equatorial line and only one layer line is present, an entirely satisfactory solution of the structure cannot be made A careful study of the equatorial interferences

indicates that the system is monoclinic, with the following unit cell dimensions  $a = 4.28 \text{ Å U}$ ,  $b = 3.78 \text{ Å U}$ ,  $c = 14.1 \text{ Å U}$ ,  $\beta = 59^{\circ}45'$  Of some significance is the fact that the identity period along the  $b$  (fiber) axis was found to be  $3.78 \text{ Å U}$ , as compared to  $3.25 \text{ Å U}$  of the sodium hydroxide compound Although this fact is probably connected in some manner with the difference in size of the two ions, no conclusive explanation can yet be given

*Addition Compound with Lithium Hydroxide*—Of the three alkali addition compounds of collagen, the lithium compound seems to be by far the most difficult to prepare Atmospheric carbon dioxide must be excluded during drying to prevent the formation of lithium carbonate The pattern of the compound is shown in Figure 6 No attempt at the solution of the crystal structure is given, although it is manifestly different from both the preceding addition compounds

#### ACTION OF HYDROCHLORIC ACID UPON COLLAGEN

Samples of tendon collagen were treated with increasing concentrations of hydrochloric acid up to the point at which rapid decomposition was produced Swelling in this case was only moderate as compared to that obtained with alkali solutions of the same strength The diffraction pattern of the dried material failed to show any evidence of a new structure

#### STUDY OF THE LONG INTERPLANAR SPACING FOUND IN COLLAGEN

For the x-ray investigation of organic materials which show interferences from interplanar spacings of not more than  $50 \text{ Å U}$ , the usual technic with the  $K\alpha$ -radiation of copper at a sample-to-plate distance of 5 to 10 cm is found to be quite satisfactory For spacings above this value the interferences are located so close to the central spot that it is always difficult if not impossible to resolve them from the trace on the film of the undiffracted primary beam Inasmuch as the value of  $\sin \theta$  varies di-



Fig 11



Fig 12

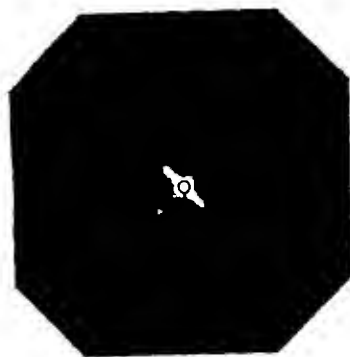


Fig 13

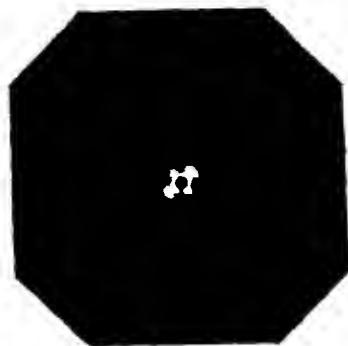


Fig 14

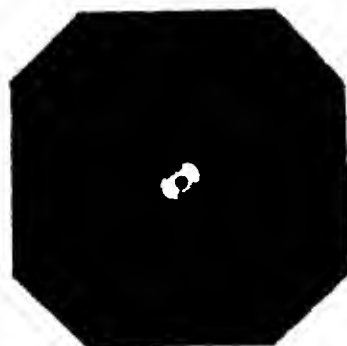


Fig 15

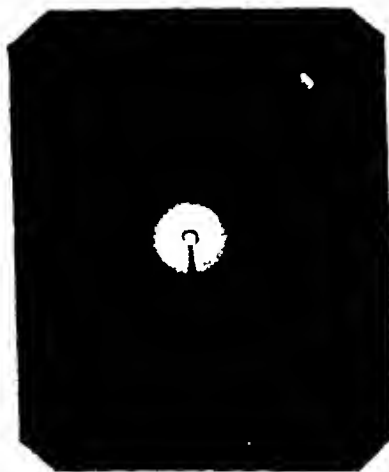


Fig 16

- Fig 11 Untreated surgical suture allowed to dry under no tension (20 cm )  
 Fig 12 Sample same as shown in Figure 11 but allowed to dry under 500 g tension (20 cm )  
 Fig 13 Sample same as shown in Figure 11 but allowed to dry under 1270 g tension (20 cm )  
 Fig 14 Extended intestinal wall collagen ribbons X ray beam perpendicular to fiber axis and parallel to plane of ribbons (10 cm )  
 Fig 15 Same sample as shown in Figure 14 X ray beam parallel to fiber axis (10 cm )  
 Fig 16 Intestinal wall collagen wax extracted with hot alcohol (10 cm )

rectly as the value of  $\lambda$  for any given spacing, the use of long wave length radiation such as the  $K\alpha$  of aluminum or magnesium

usually is resorted to in such cases. The chief disadvantage of the use of long wave length radiation is that it is readily ab-

sorbed, necessitating long exposure times and the use of very thin specimens. Also, specially built gas type x-ray tubes are usually necessary.

X-radiation of only moderate wave length such as the  $K\alpha$  of copper can be used for the study of long interplanar spacings only by increasing the specimen-to-film distance and observing great precautions to overcome inherent difficulties in technique.

To avoid scattering due to air, especially at film distances in the neighborhood of 30 cm, a special type of vacuum camera with a variable sample-to-plate distance was designed and built. The details of the apparatus will be described elsewhere. With this apparatus it was found that not only was the exposure time greatly reduced but the interferences always were much sharper. In Figures 7 and 8 are two diffraction patterns of the same sample of raw catgut material, one (7) taken in a vacuum and the other (8) taken in air, at a film distance of 10 cm, in which a very pronounced improvement due to the vacuum can be seen. For longer distances, especially at 30 cm, a tremendous improvement can be seen.

In addition to the usual diffraction pattern shown at 5 cm, described at the beginning of this article, tendon collagen shows various orders of a very long meridional interplanar spacing which has previously been mentioned (9). In Figure 9 is shown a typical pattern given by a bundle of untreated rat tail tendons at a film distance of 29.5 cm, using two 0.005 in pinholes. This particular pattern shows four distinct orders, whose "d" values were calculated to be 202, 107, 72.6, and 57 Å U. The first interference listed, although very definitely present, was difficult to measure accurately on account of its nearness to the central spot. Basing the calculations upon the third interference which is sharpest and most accurately measured, it can be seen that these values represent either the first, second, third, and fourth orders of a 216 Å U spacing, or the second, fourth, sixth, and eighth orders of a 432 Å U spacing. Other patterns of collagen at shorter film

distances show still higher orders which can be accounted for only by assigning odd order values and for this reason 432 rather than 216 is assumed to represent the real interplanar spacing. It is not impossible for the actual value of the spacing to be even some higher multiple of 432 Å U. Other forms of collagen, such as raw skin, tanned leather, bone collagen, etc., all show this long repeating unit along the fiber axis. On the other hand, the diffraction pattern of gelatin, even the very best grade in which there is no evidence of lower decomposition products, shows no long spacing whatsoever.

*Effect of Chromicizing*—Repeated measurements and comparisons of the x-ray diagrams of raw and chromicized catgut indicate that chromicizing always tends to shorten slightly (for example, to 408 Å U) the length of this spacing.

*Effect of Hot Water and Concentrated Acids, Alkalies, and Salt Solutions*—The action of hot water upon collagen is most peculiar. At room temperature water molecules are able to penetrate the lattice with ease, giving rise to intra-micellar swelling as shown by the increase in the "d" value of the 001 planes. This swelling effect is easily reversible, the lattice dimension being a direct function of the amount of water present. The long spacing is not destroyed by this process, as it appears again after drying. It has not been found possible to observe any variation in the value of the long spacing with swelling. As the temperature is increased to around 70° C, the fibers undergo a rather sudden contraction in length. The x-ray pattern of the fiber dried in this shriveled state is found to be identical with that of unstretched gelatin, showing that the contraction effect is not accompanied by a destruction of the micelles as units but, instead, only throws them into a disorganized state. Upon swelling the dried contracted fiber and drying again under a small amount of tension the x-ray pattern again shows almost perfect fibering *but no evidence of the long meridional spacing*.

Sodium hydroxide of 0.4 N strength such

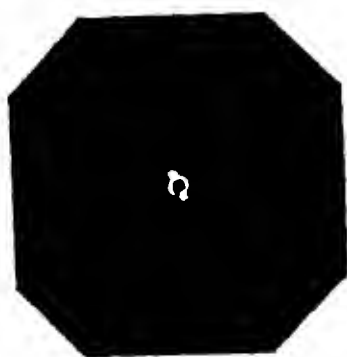


Fig 17

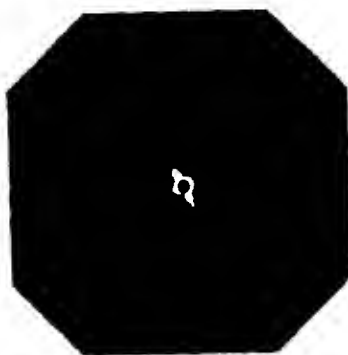


Fig 18

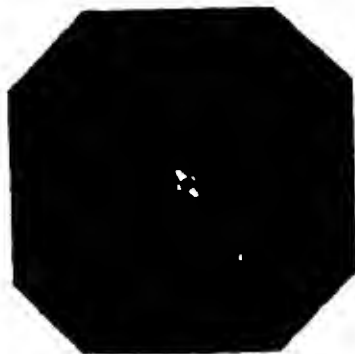


Fig 19

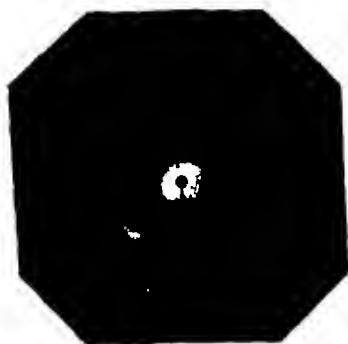


Fig 20

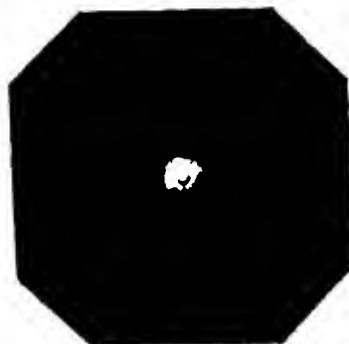


Fig 21



Fig 22



Fig 23



Fig 24

- Fig 17 Catgut suture after refluxing with benzene (10 cm )  
 Fig 18 Catgut suture after refluxing with petroleum ether followed by heating at 110° C (10 cm )  
 Fig 19 Same sample as shown in Figure 18 but subsequently swollen in distilled water and dried (10 cm )  
 Fig 20 Fresh raw intestinal wall collagen after cleaning and drying (10 cm )  
 Fig 21 Same sample as shown in Figure 20 subsequently treated with 0.25 N NaOH washed and dried (10 cm )  
 Fig 22 Same sample as shown in Figure 20 but swollen in strong NaCl solution followed by washing with Na CO<sub>3</sub> solution (10 cm )  
 Fig 23 Untreated tendon collagen x ray beam parallel to fiber axis showing Br absorption edge from 001 plane given by general radiation from copper target (5 cm )  
 Fig 24 Same sample as shown in Figure 23 x ray beam parallel to fiber axis showing same Br absorption edge from 001 plane given by general radiation from chromium target (5 cm )

as was used in studying the addition compound does not greatly affect the long fiber period provided the temperature is kept

low. Moreover, fibers treated with alkali of this strength give diffraction patterns with a large amount of scattering along the equa-

sorbed, necessitating long exposure times and the use of very thin specimens. Also, specially built gas type x-ray tubes are usually necessary.

X-radiation of only moderate wavelength such as the  $K\alpha$  of copper can be used for the study of long interplanar spacings only by increasing the specimen-to-film distance and observing great precautions to overcome inherent difficulties in technique.

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Sodium hydroxide of 0.4 N strength such



Fig 17



Fig 18

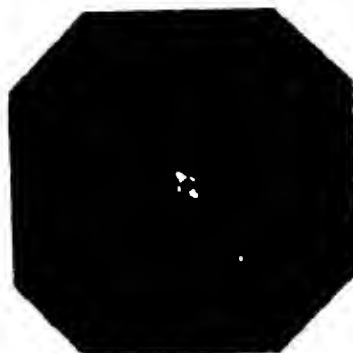


Fig 19

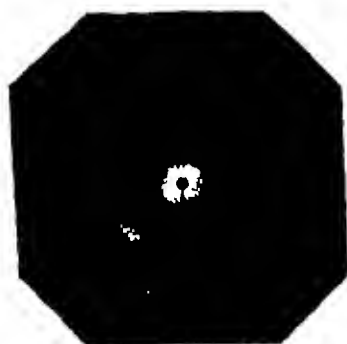


Fig 20

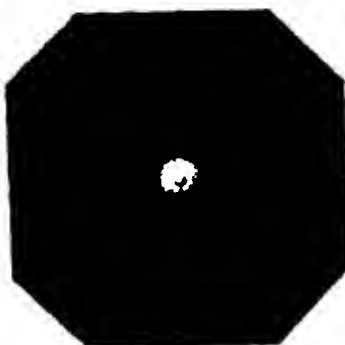


Fig 21



Fig 22



Fig 23

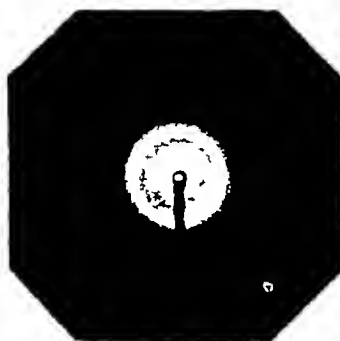


Fig 24

- Fig 17 Catgut suture after refluxing with benzene (10 cm )  
 Fig 18 Catgut suture after refluxing with petroleum ether followed by heating at  $110^{\circ}\text{C}$  (10 cm )  
 Fig 19 Same sample as shown in Figure 18 but subsequently swollen in distilled water and dried (10 cm )  
 Fig 20 Fresh raw intestinal wall collagen after cleaning and drying (10 cm )  
 Fig 21 Same sample as shown in Figure 20 subsequently treated with 0.25 N NaOH washed and dried (10 cm )  
 Fig 22 Same sample as shown in Figure 20 but swollen in strong NaCl solution followed by washing with  $\text{Na}_2\text{CO}_3$  solution (10 cm )  
 Fig 23 Untreated tendon collagen x ray beam parallel to fiber axis showing Br absorption edge from 001 plane given by general radiation from copper target (5 cm )  
 Fig 24 Same sample as shown in Figure 23 x ray beam parallel to fiber axis showing same Br absorption edge from 001 plane given by general radiation from chromium target (5 cm )

as was used in studying the addition compound does not greatly affect the long fiber period provided the temperature is kept

low. Moreover, fibers treated with alkali of this strength give diffraction patterns with a large amount of scattering *along* the equa-



torial line in the region of about  $100 \text{ \AA}$  and up. In Figure 10 is shown the pattern of the NaOH addition compound at a sample-to-plate distance of 29.5 centimeters. In this illustration the second, fourth, sixth, and eighth orders of the long meridional

contraction even at room temperature. The x-ray patterns of collagen contracted in this manner show that the long spacing has been destroyed.

Concentrated salt solutions such as lithium thiocyanate and calcium chloride were

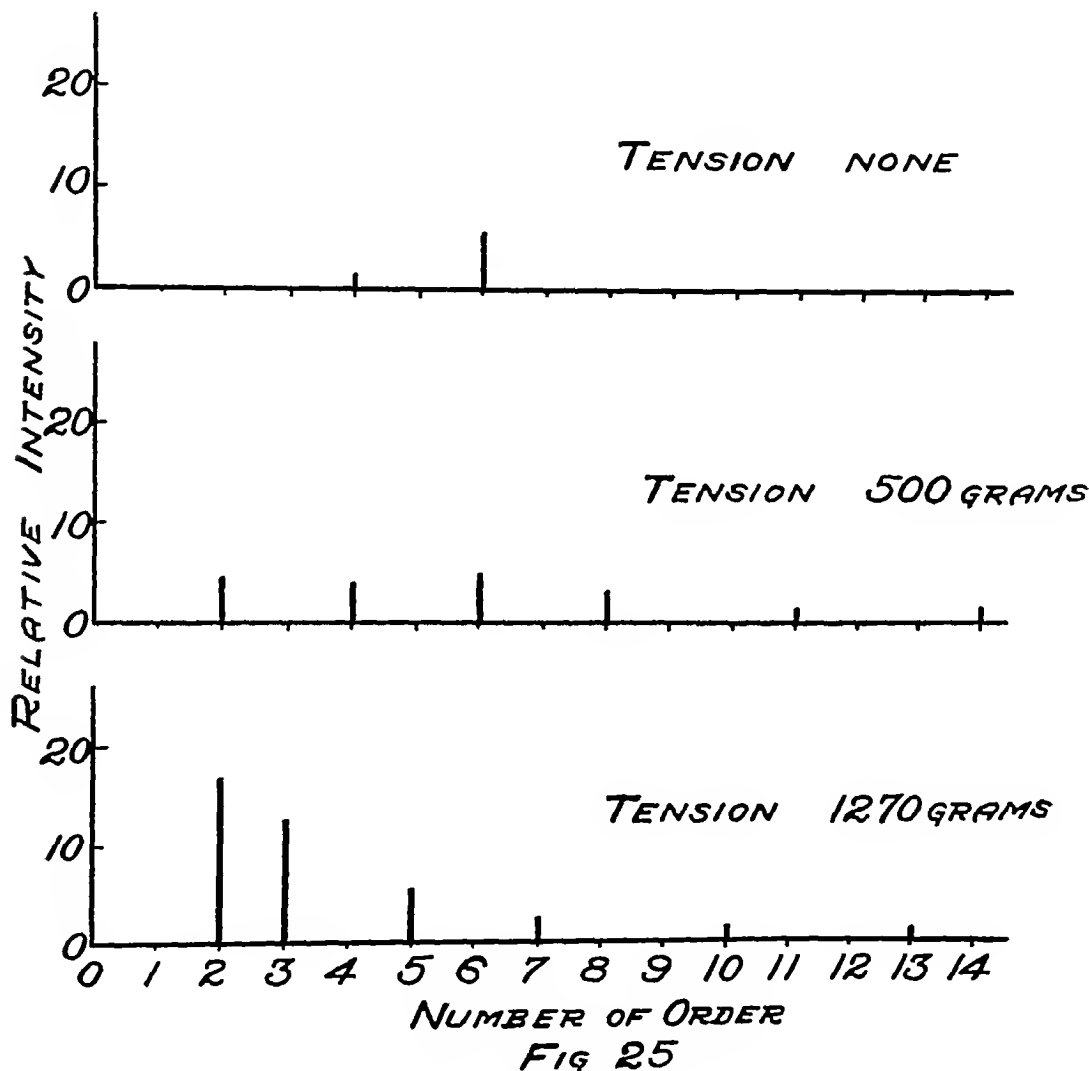


Fig. 25 Variation in intensity of different orders of the long meridional spacing produced by drying fiber under different amounts of tension

spacing as well as heavy equatorial scattering can be seen. This horizontal blackening at a very small angle is similar to that obtained for cellulose, etc., and is quite significant in that it indicates the existence of a long lateral spacing with a "d" value which is not constant. More concentrated alkalis and acids cause a great amount of

found to act very rapidly, especially upon tendon collagen, resulting in the complete destruction of the long spacing. In all cases cited above in which much contraction occurs, the destruction of the long spacing always is accompanied by a very great loss in tensile strength.

*Effect of Drying under Tension*—Drying

of the water-swollen fiber under various amounts of tension was observed to have a singular effect upon the x-ray diffraction pattern of an untreated surgical suture. In Figures 11, 12, and 13 are shown patterns of the same material swollen in distilled water for a period of three hours but dried under different loads, namely, 0.0, 0.500, and 1270 g, respectively. The last value was found to be very near the breaking load of the particular gut used. Considering only the meridional arcs given by the long spacing along the fiber axis, it can be seen that the relative intensity of the various orders appears to shift upon the application of tension, the lower orders becoming more intense. In Figure 25 is shown a diagrammatic representation of the extent to which the intensity of each order was found to vary in each of the three cases. The intensity value of each interference is a purely arbitrary one taken from the microdensitometer reading and, therefore, is only relative.

*Concerning the Nature of the Structural Unit Indicated by the Long Meridional Spacing*—Two explanations can be given for the appearance of this long meridional spacing. The first is that the protein is made up in such a manner that some particular amino acid having an extraordinarily great scattering power is periodically repeated along the chains but without any regular discontinuity in the covalent peptide bonds. The second is that the protein consists of large molecules or crystallites of a very definite length whose ends are regularly arranged in planes along the fiber axis. From the shortening effect upon the long spacing produced by chromicizing, either theory may be correct. In this process a slight crumpling of the chains which apparently takes place, would result in a shortening of the "d" value of this plane. From the simultaneous great contraction in length of a fiber and the complete destruction of the long spacing by the action of concentrated acids, alkalis and salts and hot water, the second possible explanation seems to be much more logical. The x-ray pattern shows very long molecules or

crystallites to remain after such treatment and that they may be easily oriented, but no longer is the regular periodicity along the fiber axis noted. It is difficult to see how treatment merely with a concentrated salt solution such as  $\text{CaCl}_2$  at room temperature might disrupt a covalent bond along a protein chain.

Evidently there is some sort of an attraction, probably secondary valence forces, or a powerful cementing material between the ends of the micelles in collagen. This is apparent, first, from its high tensile strength as compared to that of gelatin, and second, from the fact that although a sodium hydroxide addition compound of gelatin can easily be prepared, it cannot be made to give a well-oriented diffraction pattern. This is probably because in gelatin, the attractive forces between the ends of the micelles have been destroyed and the tension upon the ends of the molecules, so necessary for pulling the units in a definite geometric configuration, can no longer be exerted by applying tension at the ends of the protein fiber as a whole. Although not conclusive, the evidence seems to indicate strongly that this very long repeating unit is due to a definite discontinuity of the peptide bond.

A reasonable explanation of the phenomena underlying the shift in relative intensity of the different orders of the long spacing upon drying a swollen fiber under tension cannot yet be given.

#### STUDY OF THE DIFFRACTION INTERFERENCES PRODUCED BY RADIALLY ORIENTED, NATURALLY OCCURRING WAX MOLECULES ON INTESTINAL WALL COLLAGEN FIBERS

The collagenous submucous layer of the intestinal wall of animals, particularly the sheep, possesses certain peculiar properties which make it well suited for raw material in the manufacture of surgical sutures and ligatures, musical instrument strings, tennis racket gut, etc. A microscopic examination of a sheet of collagen from this source reveals its structure to be made up of tiny interwoven fibers which divide and join other fibers in such a manner as to

form a web-like structure analogous to a net. Such an arrangement gives a structure which is easily extended in any direction and has at the same time an enormous tensile strength. Aside from the advantage of being procurable in great lengths, twisted ribbons of intestinal wall collagen possess certain invaluable properties such as pliability, resiliency, etc., which might seem to be connected with the presence of thin films of highly oriented natural wax molecules surrounding the individual fibers.

Early investigators using the x-ray method found collagen from the intestinal wall to be exactly the same as that from other sources, such as tendon. The first evidence for a difference in structure of collagen from different sources was noted in the data published by Clark, Parker, Schaad, and Warren (9) for intestinal wall collagen and that by Wyckoff, Corey, and Biscoe (27) for tendon collagen. As mentioned previously, in the first article is found a reference to a long lateral spacing of  $48 \text{ \AA}$  U which was not reported in the work on tendons. Further x-ray analysis has confirmed the presence of this long lateral spacing, *peculiar to collagen of the intestinal wall*. In Figure 14 is shown the interference of this spacing with its first, second, and third orders present.

In the course of preliminary studies of the nature of this interference it was observed that, whereas the interplanar spacing of the 001 plane of collagen varied greatly with the amount of water held by the protein, the value of the longer lateral spacing was not noticeably influenced by swelling. Since these two planes are located in the same zone the swelling data indicated that the two planes could both belong to the same crystal structure only provided they were mutually perpendicular. The results of a study of the position of these two planes with respect to each other is shown in the reproduction of the x-ray patterns. In Figure 14 is shown the diffraction pattern obtained by passing the x-ray beam perpendicular to the fiber axis (long direction of stretched gut) but parallel to the plane of the gut sheets. In Figure

15 the x-ray beam was passed parallel to both the fiber axis and to the plane of the collagen sheet. The interference of the 001 plane in Figure 14 shows the protein fibers to be well oriented. The first three orders of the  $48 \text{ \AA}$  U plane are present showing it to be well oriented in the direction of the fiber axis. Figure 15 shows the plane giving the  $48 \text{ \AA}$  U interference to be oriented approximately parallel to the flat plane of the sheets, whereas the 001 plane ( $10.8 \text{ \AA}$  U) is shown to be randomly oriented about the fiber axis. From this it can be seen that these two planes, although in the same zone, are in no respect mutually perpendicular and, therefore, cannot belong to the same crystalline material.

Wax and resins have been reported to be present in surgical catgut to the extent of approximately 1.5 per cent (19). At first this small amount was considered to be insufficient to give a diffraction pattern. Furthermore, samples of raw catgut after extraction with wax and resin solvents, diethyl ether, and chloroform were found to still give the  $48 \text{ \AA}$  U spacing. However, it was noted that finished sterile ligatures which had been stored in non-boilable tubing fluid, the chief constituent of which is ethyl alcohol, did not show such a spacing. On the other hand, the spacing was always present in ligatures which had been stored in boilable tubing fluid, the base of which usually is toluene. The supposition that the crystalline material giving this spacing in the spectrum of intestinal wall collagen was of a waxy nature, soluble in hot ethyl alcohol, was easily verified. The x-ray pattern of the collagen sample extracted with hot alcohol showed no evidence of the  $48 \text{ \AA}$  U spacing. The residue obtained by evaporation of the solvent consisted of a dark brown waxy material corresponding to about 2.7 per cent by weight of the undried sample. The x-ray pattern of this waxy material is shown in Figure 16. The pattern is characteristic of that shown by most waxes. The first, third, and fifth orders of the  $48 \text{ \AA}$  U spacing are shown, which represent the length of the fully extended wax molecule. Other spacings of

08, 3'60, and 3 38 Å U also are shown, which represent lateral spacings in the molecule. Thus it is shown that the equatorial spacing of 48 Å U, which previously was thought to be given by intestinal wall collagen, actually is due to the presence of a wax of high molecular weight whose long molecules are highly oriented upon the surface of the protein fibers. In Figure 15, in which the x-ray beam was passed parallel to the flat plane of the collagen ribbons, it can be seen that the major portion of the wax seemed to be located on the surface of the sheets since the plane given by the layers of oriented wax molecules was for the most part approximately parallel to the plane of the sheets. In order to determine whether or not any appreciable quantity of the wax was fixed upon the inner fiber structure of the intestinal wall sheet, a series of partial extractions were made by treating the raw gut ribbons for short periods of time in the hot solvent and the relative rate of disappearance of the circle as compared with the strong arcs of this interference was observed. The patterns obtained from the series of these partially extracted samples of gut showed beyond any doubt that although a large portion of the wax is attached to or near the surface of the gut as a whole, the remainder must be oriented radially upon the surface of the inner fibrillar structure.

*Effect of Various Organic Solvents upon the Oriented Wax Films*—The results of extraction experiments on surgical suture samples in which benzene, chloroform, ether, acetone, and petroleum ether were used, showed that, although with each solvent a small per cent of the wax was always dissolved, in no case was the removal so complete after a 24-hour period of hot extraction that diffraction interferences could not be obtained, removal was complete when ethyl alcohol was used.

A rather peculiar result of the solvent treatment upon the effective length of the wax molecules remaining on the fibers was noted. With the high boiling solvents the 48 Å U arc usually disappeared completely after extraction and at the same time a new

diffuse ring for a spacing of about 33 Å U appeared. In the case of the low boiling solvents this change was not found unless the treatment was followed immediately by heating in the oven at 110° C. Drying in the oven to constant weight previous to the solvent treatment was found to aid greatly in this shortening effect. It must be remembered that this shortening takes place only with that portion of the wax remaining, with highly preferred molecular orientation on the fibers. That this phenomenon is only a change in effective length and not the removal or formation of another compound is evident from the fact that upon swelling the fiber in distilled water and drying again, the 33 Å U ring disappears completely, while the 48 Å U arcs return and are quite as intense as before. In Figure 17 is shown a pattern of a raw catgut suture after extraction with benzene. The presence of both the 48 and the 33 Å U spacings shows that only a partial transformation has occurred. Figure 18 shows the pattern obtained after refluxing with petroleum ether followed by heating at 110° C. A complete transformation to the 33 Å U length can be seen. In Figure 19 is shown a pattern of a sample treated exactly as described for that in Figure 18 but subsequently swollen in distilled water and dried. The last figure shows a complete reversal to the 48 Å U length. The action of the reagents described above upon the oriented film of wax can be explained best by saying that by some peculiar effect of the reagents and heat treatment the long wax molecules are caused to tilt relative to a plane to which they are perpendicular in the 48 Å U stage.

Whereas cold ethyl alcohol was found to neither produce the shortening effect nor remove the wax, the hot solution dissolved the wax completely and very rapidly.

*Chemical Analysis of Wax*—From a portion of the wax extracted with absolute ethyl alcohol the following results were observed.

(a) A few grams treated with 20 per cent NaOH and heated was seen to produce

foaming indicating that saponification had taken place

(b) No sharp melting point was observed. The melting range was found to be from  $65^{\circ}$  to  $80^{\circ}$  C, indicating a mixture rather than a single compound.

(c) A micro-analysis gave the following results

Inorganic ash	6	10%
N	1	59%
C	74	44%
H	11	50%
O		remainder

From these data the empirical formula is found to be  $C-H_{13}O$ . Assuming it to be an ester in which two atoms of oxygen are necessary, the formula would be  $C_{14}H_{26}O_2$ , which is that of an unsaturated compound. These data would seem to indicate a combination of two or more of these units to form a rather complex molecule whose effective length is  $48 \text{ \AA U}$ . However, as is shown below, the effective length of the wax molecule can be made to vary widely depending upon the pH of the solutions used in processing of the raw gut.

*Influence of Alkalies and Salts upon the Orientation of the Wax Films*—In Figure 20 is shown the x-ray pattern of raw intestinal wall collagen previous to any processing other than scraping and washing in ordinary tap water. No indication of a  $48 \text{ \AA U}$  spacing is noted but, instead, there is found an unusually large amount of amorphous scattering near the central spot. A faint concentric ring of about  $44 \text{ \AA U}$  is shown, which is due to the presence of mutton tallow and which readily disappears upon extraction with ether. This scattering effect indicates a relatively poor state of orientation of the wax molecules. In Figure 21 is shown the x-ray pattern of the same ether-extracted raw catgut after a treatment with  $0.25 \text{ N NaOH}$  for a period of twenty-four hours, followed by washing. The pattern clearly reveals the  $48 \text{ \AA U}$  spacing characteristic of catgut ligature wax. A subsequent extraction of this material with hot alcohol and evaporation of the solvent also confirmed its identity.

From these results it is definitely established that surgical ligature and suture wax is a naturally occurring material of intestinal wall collagen. The x-ray pattern of the ether-extracted material after treatment with a bicarbonate solution, followed by washing, showed only a narrow lateral band of scattering, indicating that the wax molecules were fairly well oriented but lacked something to hold them in well-defined planes, a condition which is necessary to produce a sharp interference. As the first storing medium for the fresh raw gut in the manufacture of surgical ligatures and sutures is usually a strong NaCl solution, a sample of raw gut described above was allowed to soak in such a solution for a period of twenty-four hours. The x-ray pattern of this material showed very distinctly a partially oriented ring of about  $42 \text{ \AA U}$ , besides the diffuse lateral band described above. A portion of this same sample was given an additional treatment in a strong solution of  $Na_2CO_3$ . The x-ray pattern for this sample still gave the  $42 \text{ \AA U}$  ring, but the lateral diffuse band seen in the pattern of the samples described above now was resolved into two quite distinct arcs of about  $59 \text{ \AA U}$ . The pattern is shown in Figure 22. A repetition of this work showed these values to be correct. Moreover, the diffraction pattern of the wax from part of this sample extracted with absolute alcohol revealed these same two spacings with both the first and third orders of each showing. After a further treatment of the same gut sample with  $0.2 \text{ N NaOH}$  the pattern showed only one interference, the  $48 \text{ \AA U}$  spacing common to all samples treated with strong alkali. From the behavior of the effective length of the wax molecules upon treatment with the reagents just described, it seems that the pH undoubtedly is a great influencing factor controlling orientation. Films of this wax only a few molecules thick oriented radially on fibrils evidently possess remarkable lubricating properties essential in these fascial tissues. The wax-coated protein also possesses remarkable resistance to enzyme (pepsin, trypsin) digestion.

# ABSORPTION EDGES AS AN EXPLANATION FOR SOME PREVIOUSLY REPORTED INTERFERENCES IN COLLAGEN AND GELATIN

In a previous attempt to determine the crystal structure of collagen, Herzog and Jancke (15), using copper radiation, reported an equatorial interference of  $23 \text{ \AA U}$ , which they assumed to be a lateral dimension of a tetragonal unit cell. This same spacing has since been reported by other investigators (14) but no explanation for it has been given.

In the production of x-rays the spectrum of the characteristic radiation is always superimposed upon that of the general radiation, provided, of course, the potential across the tube is of a certain minimum value, depending upon the metal of which the target is made. For diffraction work when a nearly monochromatic beam is desirable, the tube voltage always is made sufficiently high, such that the intensity of the characteristic radiation is far greater than that of the general. However, it is known that the silver bromide emulsion of the film is not equally sensitive to x-rays of all wave lengths. For a given element rays having a wave length shorter than a certain critical value are absorbed to a much greater extent than rays of a longer wave length. These critical values for Ag and Br are  $1.379$  and  $0.918 \text{ \AA U}$ , respectively. Thus for a given plane, providing its scattering power is high and the general radiation is not filtered out, there are registered upon the photographic plate, additional interferences corresponding to the wave lengths to which the emulsion is most sensitive. The diffraction angles for these interferences are, therefore, independent of the metal of the target and depend only upon the value of the interplanar spacing. Such interferences are commonly seen in patterns of inorganic crystals which show strong planes and are usually called "absorption edges."

To investigate the nature of the spacings reported in collagen, the unfiltered beam was passed parallel to the fiber axis of a bundle of rat tail tendons,  $2 \text{ mm}$  in length.

By this method the reflection from the 001 planes is very intense and conditions are ideal for showing the absorption discontinuities. In Figure 23 is shown the pattern obtained with copper radiation, and in Figure 24 is shown a pattern of the same sample using iron radiation. The two patterns are quite similar considering the difference in wave length of the  $K\alpha$  used in each case. However, a distinct inner ring can be seen which is of exactly the same diameter in both cases. By measuring the outermost edge (the true absorption edge) and taking the wave length of  $0.918 \text{ \AA U}$ , the Br absorption edge value, these rings were found to be critical absorption bands of the 001 plane. In the pattern given by copper, if the diameter is measured from the most intense portion of the ring and the wave length is erroneously assumed to be the  $K\alpha$  of copper, the value of  $23.4 \text{ \AA U}$  is obtained. This value is found to check exactly with that reported in the above reference and, therefore, there is little doubt but that the interferences listed by the authors mentioned were due to the same phenomenon. A similar explanation recently has been made to account for some anomalous lines present in the spectrum of cellulose and its derivatives (23).

## SUMMARY

- 1 The x-ray diffraction patterns of unmodified collagen and gelatin are discussed. It is pointed out that no entirely satisfactory interpretation of the crystal structure can be made from the diffraction patterns of these materials.

- 2 The preparation of addition compounds of collagen with sodium, potassium, and lithium hydroxide is described. The crystal structure of the sodium hydroxide-collagen compound is determined. The structure is found to belong to the orthorhombic system with the following unit cell dimensions:  $a = 5.32 \text{ \AA U}$ ,  $b$  (fiber axis)  $= 6.50 \text{ \AA U}$ ,  $c = 11.90 \text{ \AA U}$ . The unit cell contains two amino acid residues. The alkali-amino acid ratio is found to be approximately 1:1. The structures of the potassium and lithium compounds are

found to be different and a tentative solution is given for the potassium compound

3 Different methods in technic in the study of very long interplanar spacings are given. A periodicity of 432 Å U along the fiber axis of collagen is measured directly from diffraction interferences. The effects of chromicizing, hot water, concentrated acids, alkalis, and salt solutions and drying under tension upon the long meridional spacing in collagen are discussed and certain indications concerning the nature of the large structural unit shown by this spacing are mentioned.

4 The presence in intestinal wall collagen of naturally occurring wax molecules oriented radially upon the surface of the collagen fibers is shown to produce a lateral 48 Å U interplanar spacing previously thought to be given by the collagen crystallite itself. Studies of peculiar orientation effects of solvent treatment, alkalis, and salt solutions upon the oriented wax molecules are described.

5 Some previously reported interferences in the x-ray spectra of unmodified collagen and gelatin are shown to be due to bromine absorption edges from the 001 plane.

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# TYPHOID SPINE<sup>1</sup>

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TYPHOID fever ceased to be a common disease about the time that roentgenographic apparatus came widely into use, and while it is still present in some rural regions, it has become almost a rarity in city hospitals. Hospitalization of the C C C has brought a number of cases into the Fort Sam Houston Station Hospital from rural camps.

The text-books list "typhoid spine" among the complications, but few of the present generation of physicians have seen this clinically, and there is no reference to this condition in the roentgenologic jour-

Hospital on Aug 5, 1935. He had been visiting in the country in July. On August 10, a diagnosis of typhoid fever was confirmed by a positive blood culture. The patient was quite ill and it was thought that he would die. However, he responded to the instituted management, and on September 11, culture of feces was negative for *Bacillus typhosus*. His convalescence was slow. On October 13, he was permitted up in a wheel chair with apparently no ill effects. On October 15, he was permitted to take a few steps, at which time there were no complaints. On October 27, he be-

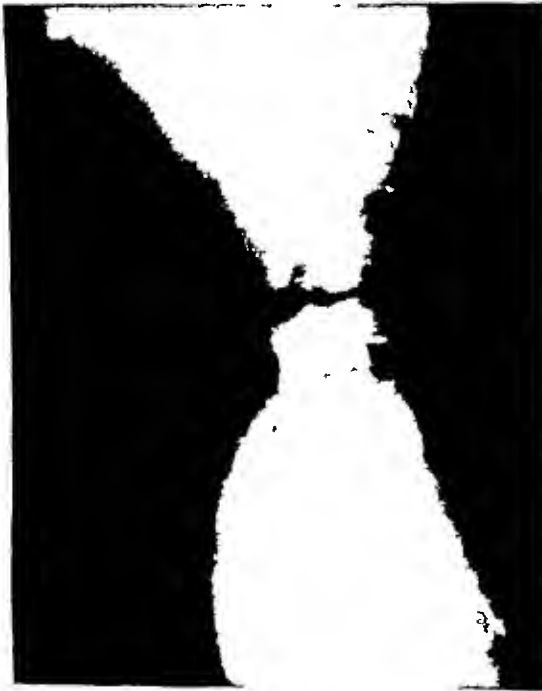


Fig 1



Fig 2

nals of the last ten years. The following case may be of interest as exhibiting rather typical typhoid spondylitis.

The patient, a civilian, son of a soldier, aged 15 years, was admitted to the Station

gan to complain of pain in the lumbar region of his spine. On examination, the patient presented a peculiar posture on standing. There was a scoliosis of the upper dorsal vertebræ, the lower dorsal and lumbar vertebræ were rigid. Viewed laterally, he presented a sway-back appearance, he could not bend forward and

<sup>1</sup> Published with the consent of the Surgeon General of the Army, who assumes no responsibility for any statements contained herein.



the spinous processes of the lumbar and lower dorsal vertebræ were tender on pressure. A roentgenologic examination of the pelvis, lumbar, and dorsal vertebræ was requested. The report follows:

Nov. 2, 1935 "The thoracic spine shows some scoliosis toward the right. No destructive lesions are seen, the intervertebral spaces appear normal. The lumbar spine shows a rather marked scoliosis toward the left. The bodies of the first three lumbar vertebræ are fairly normal, but there is some irregularity of the joint surfaces. There is some irregular absorption of the anterior portion of the body of the third lumbar. The bodies of the fourth and fifth show destructive changes, the joint space being practically obliterated and markedly irregular. The lower border of the fifth appears to be intact. There is considerable decalcification of the sacrum with outlines barely visible. No joint line is seen at the sacro-iliac articulations, and there appear to be destructive changes in the sacro-iliac joints.

*"Impression*—Typhoid spondylitis of the lumbar spine and sacrum."

Dec. 2, 1935 "There is apparently further destruction of the bodies of the fourth and fifth lumbar vertebræ. There is a long spur on the lower right border of the fourth lumbar. The bone structures in the sacrum appear more normal and better calcified, and the outlines are a little clearer."

Clinically, the patient is in a plaster shell and is quite comfortable.

A type of infectious spondylitis due to inflammatory changes in the ligaments and bones of the spine, occurring during an attack of, or convalescence from, typhoid fever was first described by Gibney as the "typhoid spine." The lumbar region is most frequently affected. According to the literature, the symptoms are paroxysmal attacks of intense pain with muscular spasm associated with tenderness. In some cases the nerve roots are involved, with sensory and motor disturbances. Spondylitis is more common in males. It may recur after apparent recovery, but permanent deformity rarely follows. Suppuration has not been observed.

Holmes and Ruggles (1) state "Typhoid spine appears in the form of localized areas of rarefaction near the corners of vertebral bodies, with local thinning of the adjacent disc and the subsequent development of a heavy bony bridge about the focus and disc."

The treatment consists in immobilization of the spine on a Bradford frame or in a plaster cast during the acute stage, which should be followed by a brace commensurate with the affected region until all symptoms have subsided, which usually requires from six months to one year. Cure is effected through proliferative changes which result in the formation of osteophytes and produce ankylosis.

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THE SIGNIFICANCE OF X-RAY CONTROL IN ARTIFICIAL FIXATION OF THE  
MEDIASTINUM SUPPLEMENTING CLOSED INTRAPLEURAL PNEUMONOLYSIS  
IN CAVERNOUS PULMONARY TUBERCULOSIS<sup>1</sup>

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**A**N artificial pneumothorax can be considered effective only if an anatomical closure of the tuberculous cavity can be proven radiographically. The clinician who, after pneumothorax treatment, is inclined to rely mainly on the improved clinical picture, gain of weight, disappearance of toxic symptoms and of tubercle bacilli, and who, therefore, considers the collapse as clinically effective, will often be disappointed to learn from the radiologist that in spite of an apparent clinical improvement the tuberculous cavity is still open and that his problem is far from being solved.

In intrapleural pneumonolysis, for instance, it happens very frequently that a tuberculous cavity does not close in spite of a successful severance of pleural adhesions by the Jacobaeus method. The reason for such failures is mostly a stiffened wall of the cavity. Surgeons like Sauerbruch, therefore, often hesitate to try this method and prefer more radical procedures, such as thoracoplasty.

We have learned from Potter,<sup>2</sup> who has probably treated the largest number of such cases, that artificial fixation of the mediastinum is an excellent aid in rendering an unsatisfactory pneumothorax effective. One allows the mediastinum, which, in the majority of such cases, is pushed over to the opposite side, to return to its normal position under fluoroscopic control and injects from 10 to 15 cc of sterile, chemically pure mineral oil into the pleural sac. In this manner one produces an artificial pleural effusion with

a temperature of 102.8 to 104° F lasting for a few days. During the following eight weeks, one fluoroscopes the patient at short intervals in order to determine whether or not the mediastinum is movable during respiration. Omission of fluoroscopy leads invariably to failures. As soon as the radiologist can prove complete fixation of the mediastinum in the mid-line, the fluid is aspirated and artificial pneumothorax continued. The tuberculous cavity closes in a great number of cases and the problem is solved. The same supplementary procedure is necessary in cases following closed intrapleural pneumonolysis, in which the cavity seems to be incollapsible for reasons mentioned above. The following case is an interesting proof.

A girl, aged 16 years, showed, on admission to the Deborah Sanatorium, Browns Mills, N J, a cavernous tuberculosis of the right upper lobe with pericavernous infiltration (Fig 1). Artificial pneumothorax was attempted for three months but the cavity failed to close in spite of high pressure insufflations, because of a pleural adhesion which held the cavity open (Figs 2 and 3). The patient was, therefore, sent to me for electrosurgical severance of the adhesion. In spite of the fact that the operation was successful, the cavity failed to close after numerous artificial pneumothoraces (Fig 4). The only change that the roentgenologist could report was a mediastinal herniation (Fig 5). In spite of clinical improvement, it was decided to follow Potter's suggestions to aspirate air, under fluoroscopic control, and to allow the mediastinum to return to its original position. A mediastinal fixation

<sup>1</sup>X-ray Demonstration Clinical Meeting St Mary's Hospital Orange N J April 14 1936

<sup>2</sup>B P Potter Preliminary Report *Aerztliche Sammelblätter* Jan 25 1935 Final report in print

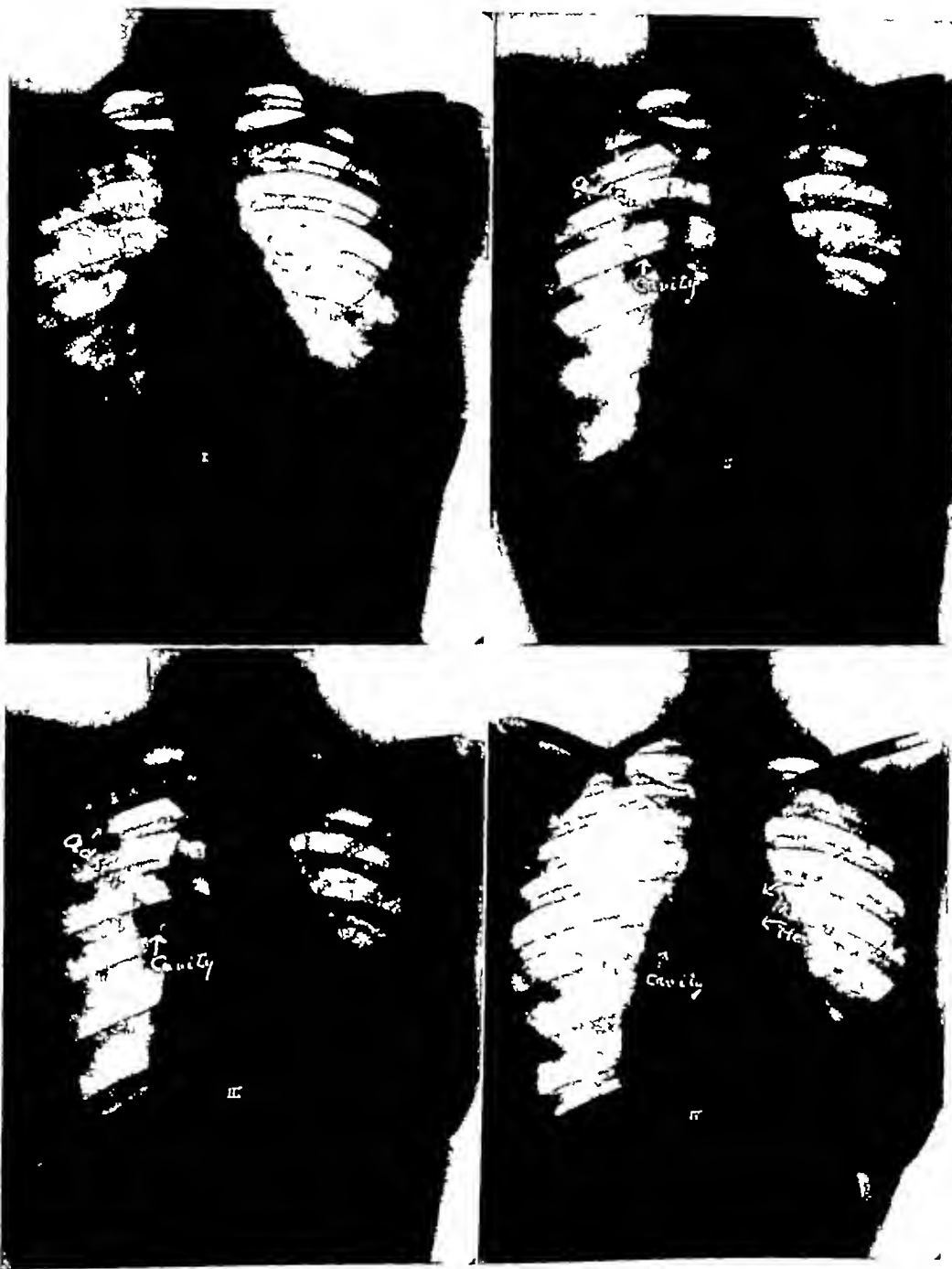


Fig 1 (upper left) Tuberculous cavity in the right upper lobe—pericavernous infiltration  
 Fig 2 (upper right) Pneumothorax ineffective on account of adhesions  
 Fig 3 (lower left) Pneumothorax still ineffective—increased intrapleural pressure  
 Fig 4 (lower right) Adhesions severed electrosurgically Cavity is still open Mediastinum has shifted to the left Mediastinal hernia

in the mid-line was then produced by artificial pleural effusion (described above) and, after aspiration of fluid, the pneumothorax was continued with small amounts



Fig 5



Fig 6

Fig 5 Cavity is still open There is increased intrapleural pressure The mediastinal hernia is larger  
 Fig 6 Mediastinum allowed to return to mid-line Artificial fixation of the mediastinum by artificial fluid formation Cavity is still open

of air given at short intervals under negative pressure (Fig 6) The attempt was successful (Fig 7) It shows a complete anatomical closure of the cavity The sputum has remained negative ever since Artificial pneumothorax is being continued

#### SUMMARY

The importance of x-ray control in cases of ineffective collapse following closed intrapleural pneumonolysis is shown A case is presented in which, after pneumonolysis, the collapse seemed to be clinically effective but proved to be anatomically ineffective as demonstrated on the x-ray film The anatomical closure was possible only after a supplementary artificial fixation of the mediastinum under x-ray control



Fig 7 Fluid aspirated pneumothorax continued Anatomical closure of cavity

# AN IMPROVED METHOD FOR MAKING REPRODUCTIONS FROM X-RAY FILMS

By BERNARD H. NICHOLS, M.D., and J. C. ROOT, M.D., Cleveland Clinic, Cleveland, Ohio

THE making of positive reproductions from x-ray films by the methods now in general use is a tedious and time-consuming task. We have sought to simplify and improve this type of work, as well as to reduce the cost in cases in which a large number of copies must be made. In addition, the method to be described provides for another means of lantern slide projection, namely, the film positive printed on a single strip of film.

The method that we have found most acceptable for this work is based on the miniature camera using 35 mm motion picture film. This film has the advantage of being very fine-grained, many negatives can be stored in a comparatively small space, and the cost per negative, when the film is purchased in bulk, is about one cent. The equipment consists of a Leica model F camera with an  $f/3.5$ , 5 cm lens, a sliding focusing copy attachment with an arm for attaching to an upright, and an illuminating box. While any available view box may be used, we feel that there are distinct advantages in the illuminator which we have designed and are now using.

The illuminator is made up of a metal box 18 1/2 inches long, 16 1/2 inches wide, and 19 inches high with welded seams. On the floor of this is a base board upon which are 12 sockets for electric lights, which are arranged in three rows of four each. The light source consists of twelve 40-watt lamps. A sheet of opal glass is placed 10 inches above the base board for primary diffusion of the light. Between this sheet of glass and the bottom of the box, vents are cut in the sides to eliminate the heat given off by the lamps. A piece of plate glass, frosted on one side, is enclosed with metal strips to form a tray. When assembled this is inserted in grooves 5 3/4 inches above the opal diffusing glass and will hereafter be termed the "sand tray." The top of the box, on which the films are

placed, consists of a second piece of opal glass 2 1/2 inches above the sand tray. Hinged to the back of the box is a heavy

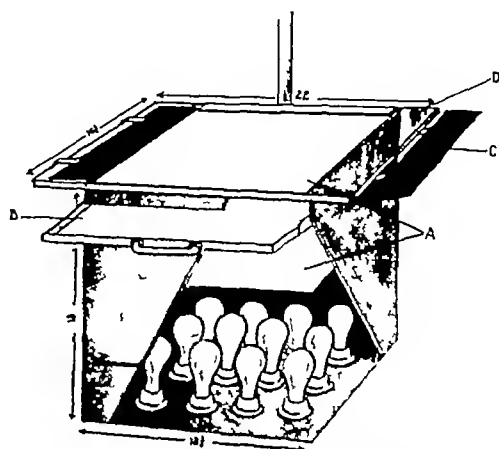


Fig 1 Diagram of illuminating box  
(A) Opal glass (B) Sand tray, (C) Mask (D) Plate glass

sheet of plate glass which serves to hold the film flat and in good contact with the opal glass top. The construction of the illuminating box is shown in the diagram (Fig 1). The metal upright, made from 1 1/4 inch tubing, is fastened to the rear of the box. For convenience, small grooves are cut in the tubing to designate the film-camera distance for the different sized films.

For operation, the apparatus is set up as shown in Figure 2. Masks may be made from black fiber cardboard to cut out any undesirable illumination coming from around the sides of the smaller films. For films of average density and light distribution, the sand tray, consisting of the frosted plate glass, may be left *in situ* and serves to further diffuse the light coming through it. If any particular portion of the film needs accentuation, this may be accomplished by means of the sand tray. In this case the tray is removed from its position and set, with the film in place, on top of the plate glass pressure plate. Fine sand from a con-

tainer is then sifted over the areas in which the intensity of the light is to be diminished. For this purpose an ordinary tin can with a fine mesh wire screen bottom may be used. The sanding procedure may be facilitated if different sized openings are available for the bottom of the dispenser. With these the sand may be better placed over small or irregular areas. After the proper amount of sand has been distributed over the surface, the tray is returned to its position below the top opal glass. In using the sand tray, the frosted side of the glass should be uppermost so that the sand will not be so apt to shift about.

The question may arise as to whether or not the sand might not cause unsightly edges or lines in the resulting negative. Since the camera is comparatively close to the object, the depth of focus is necessarily shallow, and it will be found that the distance,  $2\frac{1}{2}$  inches below the film, is ample to produce a blending or softening of the sanded areas. The depth of focus may, of course, be further shortened by using the lens with the diaphragm at a large aperture.

Many films are available in the 35 mm size, in fact, more than in any other width, which is another advantage in favor of the miniature camera, as it permits of a careful choice. In selecting a film for this specialized type of work it is absolutely essential that it be of the fine grain type since large prints or projections may be required from the negative. Speed is not a factor, hence it is better to choose a slow film since it is a well-known fact that the slower films are also the finest grained. We have found the Eastman Background Negative to be very well fitted for our purpose since it meets the stated requirements. It is of the fine grain type and has a slow emulsion, the Weston rating being twelve by daylight and eight by artificial illumination. This film is not to be confused with the Panatone, which has a similar but faster emulsion.

Using the above factors to rate the film speed the exposures may be made with the aid of a Weston meter if there is any

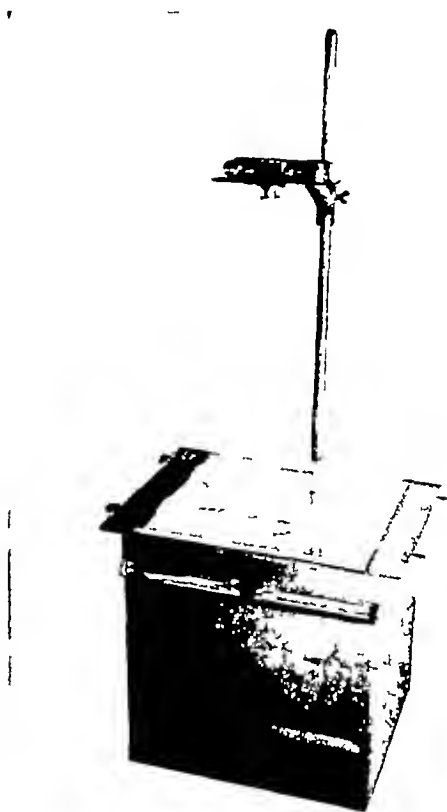


Fig 2 Apparatus as set up for use

doubt as to the correct aperture or the amount of time to use. Care must be exercised, however, to obtain the meter reading for the part of the film that is of the most importance. The proper exposure, for an average chest film as an example, will be one second at an aperture of  $f\ 11$ . With a little experience, the exposure factors may be estimated and, to speed up the work, one may dispense with the meter.

Processing the film is a simple procedure, and it will be found that perfect results may be obtained if ordinary care is used. It is, of course, as important to use a fine grain developer as it is to use a fine grain film. Here, too, there are many choices as there is an infinite number of different kinds of developers. However, since our primary object is to use the simplest methods consistent with good results, we must look for an easily prepared solution with a short

developing time. Such a preparation is the Eastman Ultra-fine Grain Developer which may be procured already mixed, in a dry form, so that it is only necessary to add water. This, we believe, will give as fine a grain as paraphenylenediamine, and requires only a fourth of the time needed for the latter. Development by time and temperature is the most satisfactory method, and properly exposed films will yield good negatives if developed for  $8\frac{1}{2}$  minutes at a temperature of  $65^{\circ}\text{F}$ . The fixing and washing is carried out as with any other type of film. It may be desirable, however, to use an additional hardening bath to prevent scratches and other markings that might come from handling or rubbing of the surfaces together with dust in between.

#### COMMENT AND SUMMARY

A simplified process for the reproduction of x-ray films has been described. Less time is consumed in making the exposures than in the methods now in general use since it is only necessary to wind the film and there are no film holders to load and change for each exposure. The cost per negative is low and will be about one cent if the film is purchased in bulk.

Another advantage to bulk film is the fact that as much film as needed, from a few to 36 exposures, can be loaded in the magazine as is desired. The advantage of developing 36 exposures on a single strip

of film can readily be seen when one considers the work required to process an equal number of cut films or plates. The problem of storage is a minor consideration but is nevertheless a point to bear in mind if a large number of copies is to be made.

The negatives, after they have been processed and dried, may be used in a number of ways. For projection, excellent results may be had by using the 35 mm projector, the negatives of which may be used without further printing, or positives may be made either on 50 mm slides or on a positive film strip (1). The latter method of showing reproductions is very convenient if travelling, as the weight of the projector and 100 or 200 pictures will be less than that of 50 standard lantern slides. Other uses are in the making of standard lantern slides, prints, or transparencies. These are, of course, all made by enlarging so that they may be of practically any size desired.

The present trend in reproduction seems to be toward the use of positive pictures so that the copy has the same characteristics as the original film. Hence, it is felt that the simplified and inexpensive method of securing such reproductions which are presented here may be of value to others confronted with the problem of producing satisfactory positive reproductions.

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# CASE REPORTS

## HYPERPARATHYROIDISM CASE REPORT

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and L. R. LINGEMAN, B. S., M. D., Rochester, N. Y.

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Hospital

The patient, Mrs. A. C., No. 75,021, white, female, aged 33 years, was admitted to the Rochester General Hospital on July 25, 1932. She complained of pain in the feet, legs, and back, causing difficulty in walking and constant fatigue. She had been first seen on July 22, 1932, because of the above complaints. The finding of a tumor in the right side of the neck and marked osteoporosis of the spine and pelvis, as revealed by an x-ray examination, led to a tentative diagnosis of hyperparathyroidism and she was referred to the hospital for further study.

The past history was unimportant.

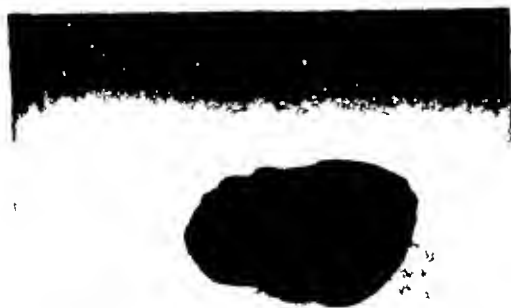


Fig. 1 Gross appearance of the parathyroid tumor

The present illness began about eighteen months before admission. She had been forced to give up her work in a tailor shop because of the pain in her feet, legs, and back. The pain in her extremities seemed to be affected by changes of weather and she was treated for about six months for rheumatism without relief. She had one severe attack of colicky pain in the right upper quadrant in 1931, diagnosed as "gallstone colic." She also gave a history of two falls within the year previous to her admission, apparently unrelated to her present complaints. There had been some constipation and nocturia.

Physical examination reveals a fairly well nourished Italian female who appears to be in

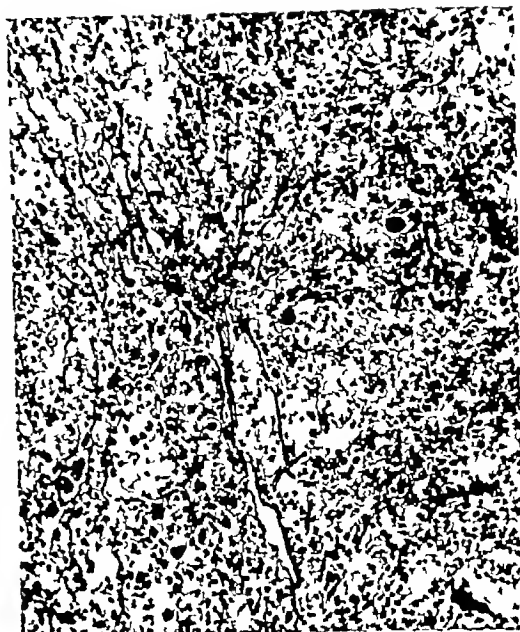


Fig. 2 Photomicrograph of the parathyroid tumor presenting similarities to the structure of hypernephroma

pain on all motion of the back and lower extremities. There is a small nodule below the right pole of the thyroid. The thoracic cage shows marked deformity, there being a deep depression running parallel to the sternum at the costochondral junction. The lower extremities seem atrophic, particularly the left. There is pain on pressure over the ribs, spine, and pelvis.

**Orthopedic Examination**—The patient walks with a very waddling hip gait and stands with marked dorsal kyphosis. Both feet are flat and tender. There is scarcely any lumbar motion in any direction. The pain is not localized, but is present all around the lower back. Lower extremity motions are all carried out with much effort and considerable complaint. There are definite sacro-iliac findings. There is marked atrophy of the gluteals and muscles of the lower extremities.

Films of the chest show marked deformity of the ribs anteriorly and laterally. Examination of the spine and pelvis shows marked osteoporosis. The density of the bones of the upper extremities appears to be almost normal. A film of the femur shows marked osteoporosis.

### LABORATORY EXAMINATION OF THE BLOOD

July 22 1932	Calcium—14.8
	Phosphorus—2.2
Aug. 6 1932	Calcium—13.8
	Phosphorus—2.2



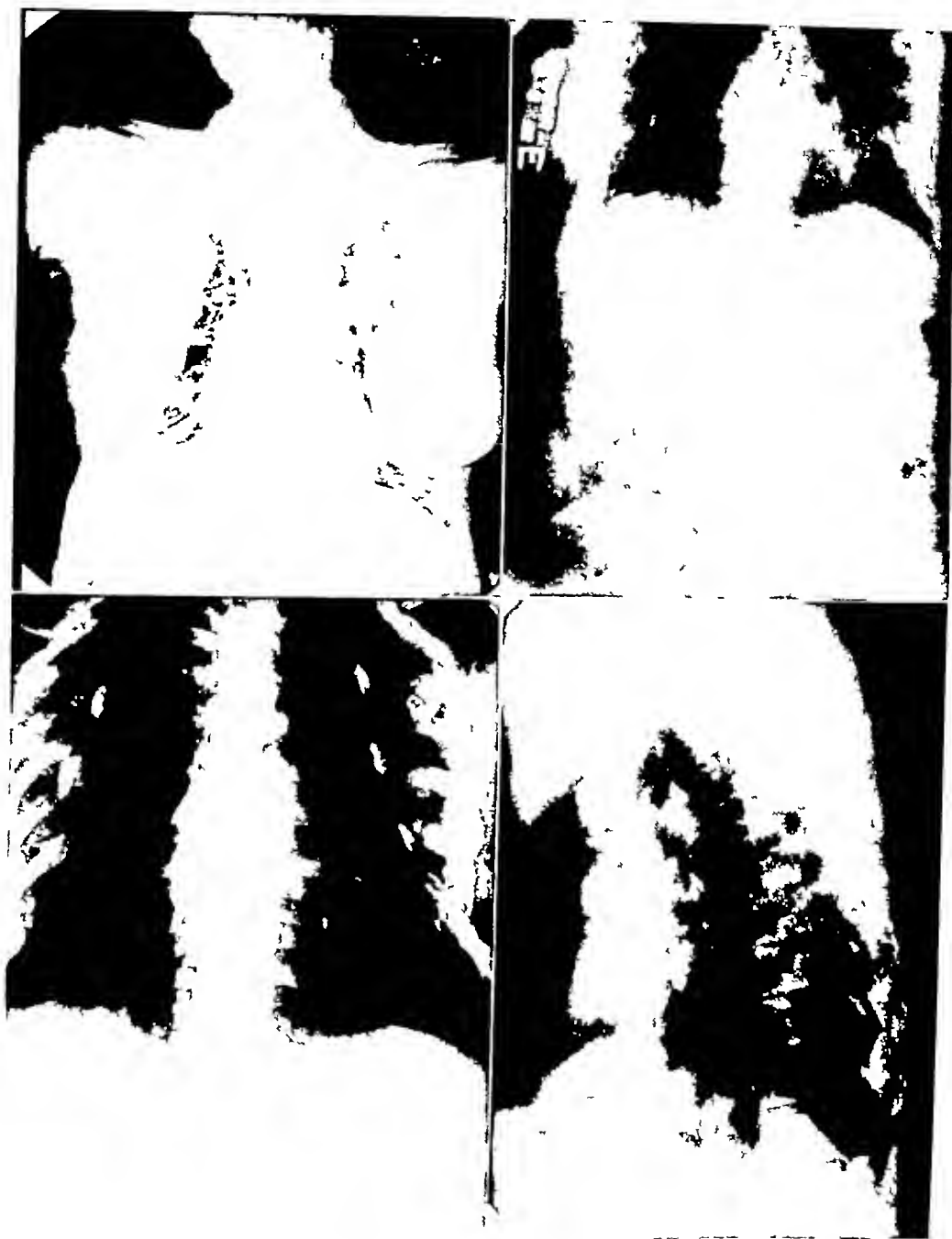


Fig 3 (*upper left*) Chest film made before operation. This film was one of several made in attempting to get a satisfactory one. Note the deformity at the costochondral junction.

Fig 4 (*upper right*) This film of the lower thoracic and lumbar spine shows the lack of density and the deformity of the spine and ribs. Compare with Figure 5.

Fig 5 (*lower left*) This film was made after the operation and return of calcium and phosphorus to normal levels. Compare with Figure 4.

Fig 6 (*lower right*) A lateral film of the thoracic spine. Compare with Figure 7 which was made after the operation.

On Aug 6, 1932, a parathyroid adenoma (Fig 1) was removed from the right side of the neck

#### REPORT OF THE PATHOLOGIST

The specimen is a tumor  $32 \times 19 \times 17$  mm in size, the shape of an olive, which seems to be well encapsulated except for a single area, 1 sq cm in size, evidently the place of surgical removal. On cut section, it is found to be formed of compact parenchymatous yellowish-white tissue. No colloid is seen.

**Histology**—The tumor is composed of tumor cells which are arranged in broad or thin sheaths (Fig 2). The nuclei are round and the protoplasm stains light. There is a fairly well-defined cell border. Toward the periphery, the cells become large, with various sized, often giant, nuclei, and a huge protoplasm. These cells are in frequent instances similar to the cells of the adrenal cortex.

**Diagnosis**—Parathyroid tumor, possibly malignant

#### BLOOD EXAMINATION

On Aug 8, 1932, forty-eight hours after operation, it showed the following

Aug 8 1932 (48 hours after operation)	Calcium—10.4 Phosphorus—1.8
Aug 9, 1932	Calcium—8.2
Aug 10 1932	Calcium—8.2 Phosphorus—3.4
Aug 12 1932	Calcium—7.5 Phosphorus—8.4
Aug 16 1932	Calcium—7.4 Phosphorus—5.0
Sept 7 1932	Calcium—10.4
May 21 1933	Calcium—11.7
(?) (Quantity not sufficient)	

The patient developed a psychosis the day following her operation. She became excited, irrational, and had delusions. This condition cleared in about one week.

She was discharged to the Out-patient Clinic on Sept 9, 1932. Since her discharge, she has shown continuous improvement in her condition. She was last seen on May 28, 1934, at which time she was not only symptom-free, but her blood calcium and phosphorus were normal. An x-ray film of her bones showed about normal density.

#### CONCLUSIONS

We have reported a typical case of hyperparathyroidism, due to a parathyroid adenoma. The interesting features are: The deformity of the thoracic cage, due to atmospheric pressure, and muscle pull on the softened ribs, pains in the back and lower extremities with atrophy of muscles, general weakness and constantly maintained fatigue posture, general-



Fig 7 Compare with Figure 6. Note the increased bone density and the deformity of the lateral aspects of the ribs.

ized tenderness over the bones, a history of constipation and polyuria, the fortunate location of the parathyroid adenoma, the prompt fall in the blood calcium, the post-operative psychosis, and, finally, the complete clearing of symptoms following the removal of a parathyroid adenoma.

We are indebted to Dr Istvan Gaspar for the description of this tumor and for the laboratory work.

#### THE TREATMENT OF RHINOSCLEROMA WITH ROENTGEN RAYS

By GUSTAV PETER, M.D., Mexico City

Translated from the German by E. T. LEDDY, M.D., Mayo Clinic, Rochester, Minn.

One of the most favorable fields in roentgen therapy is the treatment of rhinoscleroma, a lesion which is very common in Central America among the poorer classes and is usually recognized early and treated with good results. However, there are many patients who come to the roentgenologist after their ailments have been misdiagnosed as syphilis, leprosy, and so forth, having marked deformity, with extensive foul-smelling ulcerations which make



Fig 1-A

Fig 1-B

Fig 1-C

Fig 1-A  
Figs 1-B and 1-C

Before treatment  
One half year after treatment



Fig 2-A (top) Before treatment  
Fig 2-B (bottom) After treatment

the patient almost a social outcast, or at least limit the likelihood of his employment.

When I first began practice in Mexico City about fifteen years ago I had the opportunity of observing such a patient (Fig 1-A). At that time there was no mention of this condition in the roentgen literature which was available to me. I, therefore, felt my way along in the attempt to test the sensitivity of this lesion toward x-rays by giving low doses at long intervals, thereby obtaining a surprisingly good result. The objectionable odor of the ulceration had markedly decreased after the first treatment and entirely disappeared shortly after that. The ulcerated areas cleaned up and healed within a few weeks, with the result that there was a disappearance of the ulceration in the nose, lips, and gums (Fig 1-B). The defect was covered up so completely by a prosthesis with a mustache that no visible trace of the severe disease could be detected (Fig 1-C). The man returned to work in a short time.

I obtained comparable results in many other cases. Early mild cases were healed in three months, severe ones in about a year. Patients with involvement of the larynx which produced aphonia and difficulty in breathing became symptom-free in from four to eight weeks. The voice returned, and in some patients, who were in danger of losing their eye sight because of involvement of the lachryman canal, the lesions healed up rapidly and completely. Only one patient died shortly after beginning treatment. In spite of the patient's extreme asphyxia we had to begin treatment, and in spite of a low total dose of 600 international roentgens through a small field his dyspnea increased to the extent that tracheotomy was necessary. This produced



Fig 3 A

Fig 3 B

Fig 3 C

Fig 3-A Before treatment  
Fig 3-B During treatment  
Fig 3-C One year after treatment



Fig 4 A (top) Before treatment  
Fig 4 B (bottom) After treatment



Figs 5 A and 5 B Actually in treatment

only slight and temporary relief and the patient succumbed shortly after from heart failure secondary to the chronic asphyxia

Profiting by this experience we always start our larynx cases with low doses given very carefully, often with 20 r. If there is even the slightest reaction which produces swelling, we interrupt treatment for a day, or even a week. In the course of time I have worked out the following technique which best suits the most frequent nasopharyngeal cases and which usually produces prompt healing of the lesion.

After protection of the eyes and cheeks, an anterior field is given over the nose and mouth, and, if it is indicated, lateral fields may be used

in addition I use a hard radiation of a H V L 10 mm copper, and an intensity of from 5 to 12 r/min, a field of 10/15 cm with a Holfelder cone, and give daily, or every other day, a dose of from 100 to 150 r measured on the patient's skin with a Mekapion up to a total dose of about 1,000 r, and then after a rest period of from 6 to 10 weeks, usually 8 weeks, I repeat the series two to four times, giving, respectively, 800, 700, 600, 500 and 300 r. Oftentimes, because of the economic condition of the patient, it becomes necessary to modify the basic technic, and this is particularly true of patients who come from a long distance. Case M (Fig 3) received 3,000 r in 13 months, he received 800 r at the start in the first series, which consisted of two fractions of 250 r and two of 150 r.

Localized lesions in the nose, gums, or pharynx may be taken care of by radium tubes containing from 10 to 50 milligrams. A few days after a single or fractioned dose of 80 mg-hr, filtered by 0.3 mm brass or of 250 mg-hr, filtered by 0.8 mm brass (corresponding to 300 r of hard beta or 1,200 r of soft gamma radiation), there follows definite regression of the lesion. With the higher dosage there follows a fibrinous mucositis. When this reaction has subsided, further treatment is given if it seems indicated.

If the patient has sufficient time at his disposal, the treatment can be carried through with an almost constant satisfactory result. I have never seen any radioresistance of the tissues even when the treatment was markedly protracted because of the difficulty of the patient's return.

It may well be that the application of still higher doses in much shorter time by fractionated treatment as outlined by Miescher, Schinz, Borak, and others might produce equally satisfactory results with less difficulty. However, because of the relative benignity of the lesion in question, in contrast to carcinoma to which the method is best adapted, I have not used this technic because of the possibility of some late injury following treatment. With the technic I have described no late damage has appeared up to date.

In later years, there have been many reports in the roentgen literature of results similar to those of mine from other treatment technics.

A critical review of the literature has been given by Martenstein and Jung from Jadasohn's Clinic (Breslau, 1929), in *Strahlen therapie*, 33, 220. A Russian work by Kruglikowa, reporting on 172 cases and giving very instructive illustrations, appears in *Strahlen therapie*, 1934, 50, 340.

## EPILEPSY ASSOCIATED WITH BRAIN CALCIFICATIONS

### A CASE REPORT

By EDWARD LEEF M D *San Francisco*

Department of Radiology Stanford University School of Medicine

There have been several reported cases of calcification in the brain associated with epilepsy and facial nevi. However, these cases are rare, so any new case somewhat similar to these is deserving of report.

The condition has been given several names, among them being Parkes Weber—Dimitri's disease as suggested by Krabbe (1), Parkes Weber (2) having first described the condition in 1922, and Dimitri (3) having presented a case in 1923. However, it was Wissing, in 1921, who first demonstrated the roentgen changes, but the report was not published.

The calcifications are unique in that they appear to be tubular and corkscrew-like and seem to follow the outlines of the gyri of the brain. At first the calcifications were thought to be in blood vessels or in the pia, but the location was not proved until 1934, when Krabbe (1) reported six cases, one of them coming to autopsy. Each of these six cases

showed the characteristic calcifications, five in the occipital region and one in the parietal region. The microscopic examination of the material obtained from autopsy showed that there was no calcification in the pia, either in the connective tissue or in the vessels, but that the calcifications were situated in the cerebral cortex, being located for the most part in the second and third layers. The calcifications bore no relationship to the blood vessels.

The reason for the tubular appearance of the calcifications is that the thin layers of calcification are separated from each other by the first layers of the cortex and by the pia mater. The writer has reproduced the X-ray appearance by taking a specimen brain and coating the gyri with silver nitrate, which penetrated a short distance into the cortex. Since the brain was a little dry, the convolutions were separated from each other by a few millimeters and the coating of silver nitrate thus, too, showed a tube-like structure in the film (Fig 1).

The case here presented (Figs 2 and 3) shows the changes in the left fronto-parietal region of the brain. The patient, unlike most of the others, shows no facial or cranial nevi. She was referred to the X-ray Department by Dr Schaller (4), who wished to have studies of the skull because of the patient's long history



Fig 1 Specimen brain, showing a reproduction of the tubular densities



Fig 2 Shows tube like calcifications in left parietal region

of epilepsy. It is through the courtesy of Dr Schaller that the writer is presenting this case. Dr Schaller obtained the following history from the mother of the patient:

Miss M. B., aged 17 years, an American schoolgirl, clinical diagnosis, epilepsy. From the age of one or two years the patient suffered from slight epileptic attacks. Recently, however, the attacks have become more severe, occurring at intervals of from seven to ten days, coming on without warning but with loss of consciousness. The attacks are real convulsive seizures, with distortion of the features and accompanied by loud screaming.

The physical examination showed a rather heavy type of child, with a square face, some coldness of the extremities, and slight enlargement of the thyroid. The reflexes, motor system, co-ordination, cranial nerves, and eye-grounds were all negative. No nevi are present.

Examination of the films shows the tubular-shaped corkscrew-like calcifications in the left fronto-parietal region, apparently following the outlines of the gyri of the brain in that region. The pineal gland is so faintly calcified that it can be seen only in the lateral views of the skull. However, in these views the position of the pineal gland does measure three millimeters forward from the forward limit of normal. This forward displacement may be due to atrophy in the region of the calcifications. Studies of the skull using air have not been made.

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Fig 3 Same case as shown in Figure 2 posterior view

#### CONGENITAL BRONCHIECTASIS

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It is no doubt true, as Reitter<sup>1</sup> says, that comparatively few cases of congenital bronchiectasis as such have been reported in the litera-

<sup>1</sup> REITTER, GEORGE S. *Congenital Bronchiectasis in Children* *RADIOLOGY* October 1935 25, 495-497



Fig 1 Congenital bronchiectasis before lipiodol



Fig 2 Congenital bronchiectasis after lipiodol

ture That is because there is a great divergence of opinion regarding the pathogenesis of bronchiectasis Many writers still consider that bronchiectasis is in most cases secondary to other pulmonary diseases, but the volume of opinion has gathered during recent years in favor of a congenital origin of bronchiectasis, particularly in children Lipiodol bronchography has helped considerably in elucidating this vexed problem By its means, it has been possible to detect a very large number of cases of bronchiectasis during recent years Besides, it has revealed the existence of a form of bronchiectasis, the so-called dry type, in individuals who are apparently symptomless

On the basis of (1) the reports of cases of fetal bronchiectasis, (2) the occurrence of bronchiectasis in early childhood without antecedent acute pulmonary infections, and (3) the incidence of the dry type of bronchiectasis in the apparently healthy, one of us (R V) put forward the following theory regarding pathogenesis, when speaking before the Andhra medical conference, in June, 1935 The clinical manifestation of bronchiectasis is the result of a pyogenic infection occurring on congenitally dilated or congenitally weak bronchial walls According to this theory, almost all the cases of bronchiectasis in children are congenital in origin, and the dry type with occasional cough and scanty expectora-

tion is merely a stage in the development of the disease

The case reported below is particularly interesting because of the peculiar clinical history and the striking radiographic appearances, before and after lipiodol

S, a Hindu male child, aged one year and three months, was admitted on Jan 11, 1935, to the King George Hospital, vizagapatam, the complaints being extreme emaciation, slight cough, and infrequent fever During the first eight months of its life, the patient was said to be perfectly healthy in every way, but since that time he had gradually become emaciated, with a slight gastro-intestinal upset. Two months later he developed a dry cough which disturbed him, especially during the night Previous to admission the patient had been treated by various doctors, each one having diagnosed the case differently Thus he was treated for marasmus, tuberculosis, bronchitis, congenital syphilis, avitaminosis, etc

When the case was brought to the notice of one of us (R V), the patient presented the typical picture of a "wizened old man," with sunken eyes, hollow cheeks, wrinkled skin, and practically no subcutaneous fat in any part of the body Physical examination of the chest revealed marked displacement of the trachea and apex beat to the left, impaired movements, diminished resonance on

percussion throughout the left side, distant bronchial breath sounds, and a few râles. The little sputum and the stomach contents which he vomited occasionally after a fit of coughing, contained no tubercle bacilli.

A radiograph revealed a remarkable appearance. There was a uniform opacity throughout the left side, but with vacuole-like spaces varying from the size of a pea to that of a marble, perceivable through the haziness. Lipiodol injection was done under general anesthesia. A subsequent radiograph showed numerous circumscribed cavities of

different shapes distributed throughout the left side.

The above findings are sufficient to warrant a diagnosis of congenital bronchiectasis with atelectasis. Even though the child was apparently healthy for eight months after birth, there is no history of acute pulmonary disease to cause secondary bronchial dilatation. It is, therefore, justifiable to consider that in this case bronchiectasis existed from birth and that the symptoms developed after the eighth month consequent on a chronic bronchial infection.

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# EDITORIAL

LEON J. MENVILLE, M.D., *Editor*

HOWARD P. DOUB, M.D., *Associate Editor*

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## WHAT THE FEDERAL HOUSING ADMINISTRATION STANDS READY TO DO FOR RADIOLOGISTS

The radiologist, in order to give the best possible service in his important and responsible work, which may mean the life, health, and well being of many people, should have the best obtainable dependable equipment and machinery. This, however, ordinarily calls for large expenditures of money not always immediately available.

The National Housing Act, through the modernization credit plan of the Federal Housing Administration, offers to responsible radiologists means for obtaining this necessary equipment and machinery on convenient terms extending over a period up to five years.

This modern partial payment plan gives the purchaser the benefit of low prices offered customarily only to cash buyers, and at the same time the advantages of extended credit. Through this plan the buyer may obtain his material immediately and have the benefit of its use while making the required monthly installments.

The prospective user of modernization credit does not apply for funds to the Federal Housing Administration, which lends no money, but to a bank, building and loan association, or other private financial institution insured by the Federal Housing Administration against loss as a result of advances of credit to be used for modernization purposes.

Because of this governmental insurance it is possible to lend larger amounts at a lower rate of interest and for longer periods than would otherwise be possible.

The amount that may be acquired for insured modernization credit will be determined by the credit of the borrower and the location of his work rooms. If the radiologist has his offices in an apartment or office building, hospital or other Class A property, amounts up to \$50,000 are available to those of acceptable credit rating for the rehabilitation of properties and the purchase and installation of

equipment and machinery necessary in his work.

If, however, his laboratory is located in his home or other private dwelling, he is limited to \$2,000, which may be used for structural additions, alterations, and repairs only.

The amendments to the National Housing Act extended the modernization credit provisions of the Federal Housing Administration one year to April 1, 1937. They provided, also, that the borrower must be the owner of the property to be modernized or must have a lease on it extending six months beyond the period of the loan. Purchase and installation of portable machinery or equipment as well as new construction on vacant property are ineligible.

Loans of \$2,000 or less are eligible for insurance only if the proceeds are to be used to finance structural repairs, alterations, or additions upon existing buildings. Borrowers up to \$2,000 may use it for such purposes as painting, decorating, the installation of modern heating, plumbing, wiring, and similar systems.

On Class A properties the above improvements may be made with loans up to a maximum of \$50,000, and, in addition, certain equipment and machinery may be purchased and installed, provided the amount borrowed for this specific purpose exceeds \$2,000.

The responsible applicant for modernization credit under the Federal Housing program will find that obtaining funds from an approved lending agency is a simple procedure. He will present a credit statement and an estimate of work to be done, and if acceptable to the private financial institution, the necessary amounts will be forthcoming without undue delay.

The amount of credit and time allowance, interest and service charges will be the subject of mutual agreement between the borrower and lender.

The lending agency is usually qualified to pass upon eligible equipment, but in case of doubt, correspondence with the national headquarters of the Federal Housing Administration in Washington will result in specific rulings if a complete description of the article desired, accompanied by a photograph or other picture, is sent

The radiologist may be particularly interested in acquiring radiotherapy apparatus (non-portable), ultra-violet apparatus (non-portable), x-ray generators, x-ray tables, x-ray units (non-portable), diathermy apparatus, multiple wave generators, short wave diathermy units, etc., and will find that the use of the Federal Housing program offers him unusual advantages in the way of terms and credit

The following classifications of equipment are, subject to the general principles of eligibility as stated, eligible for professional and office use

Anesthesia machines (installed)  
Autoclaves  
Artificial fever apparatus (installed)  
Centrifuges (installed)  
Deep therapy tube stands  
Dental equipment (installed)  
Diagnostic machines (non-portable)  
Electrocardiographs (installed)  
Foot manipulation machines, installed types  
Hemoglobinometers  
Hydrotherapy apparatus (installed)  
Infra-red lamps—professional (non-portable types)  
Lighting systems—emergency  
Mercury lamps (non-portable)  
Operating tables  
Optometric equipment  
Oxygen tents (non-portable, hospital types)  
Resuscitators and inhalators (non-portable)  
Solar arc lamps (non-portable)  
Sterilizers (electric or gas)  
Suction and pressure units  
Transformers (current)  
Vapor baths, cabinet types (installed)  
Fluoroscopes, horizontal and vertical (installed)

## ANNOUNCEMENT

### POSTPONEMENT NOTICE

The First International Conference on Fever Therapy, originally scheduled for the end of

September, 1936, has been postponed because of numerous requests, to permit more time for the preparation of material. The new dates set for this Conference are March 30 to April 2, 1937. The sessions will be held at the College of Physicians and Surgeons, Columbia University, New York City

The advances in the treatment of gonorrhea, syphilis, and other diseases by pyretotherapy are of great social significance. Invitations on behalf of the Conference will be issued by the State Department of the United States to Ministries of Public Health of other countries. The Medical Departments of the Army, the Navy, and the Public Health Service of the U S A will be represented, as will also the New York City Departments of Health and of Hospitals

A tour has been arranged to take place immediately following the Conference, to enable physicians to observe the technics employed in fever therapy in some of the hospitals in the eastern section of the United States. Among the institutions to be visited are the Strong Memorial Hospital of the University of Rochester, N Y, the Henry Ford Hospital, Detroit, Mich, the Mayo Clinic, Rochester, Minn; the Kettering Institute for Medical Research at the Miami Valley Hospital, Dayton, Ohio, Northwestern University Medical School, Chicago

Further information regarding the Conference may be obtained from the General Secretary, Dr William Bierman, 471 Park Ave., New York City, U S A

## COMMUNICATIONS

### THE ILLINOIS RADIOLOGICAL SOCIETY

The quarterly meeting of the Illinois Radiological Society was held in Bloomington, at the Hotel Rogers, on Sunday, July 26

At a film clinic interesting cases were presented by Dr Halley, Dr Rypins, and Dr Henley

Dr P G Melnick and Mr Albert Bachem discussed 'The Time Factor in the Irradiation of Malignant Tumors,' and Dr A H Arneson presented a paper on 'Radiation Therapy in the Treatment of Malignant Diseases'

# EDITORIAL

LEON J. MENVILLE, M.D., *Editor*

HOWARD P. DOUB, M.D., *Associate Editor*

## WHAT THE FEDERAL HOUSING ADMINISTRATION STANDS READY TO DO FOR RADIOLOGISTS

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Discussion opened by T D CUNNINGHAM, M.D., Denver

Review of Year's Progress in Radiation Therapy PAUL R WEEKS, M.D., Denver  
Radiation Therapy in the Treatment of Carcinoma of the Intra-oral Cavity, Larynx, and Pharynx J M MARTIN, M.D., F.A.C.R., Dallas, Texas

The Management of Carcinomas of the Breast. CLYDE K EMERY, M.D., M.R.C.S., L.R.C.P., Pasadena, Calif

Discussion opened by W W WASSON, M.D., Denver

Round Table Discussion of Therapeutic Radiology Chairman, SANFORD WITHERS, M.D., Denver

Chaoul Therapy as Practised in European Clinics EUGENE P PENDERGRASS, M.D., F.A.C.R., Philadelphia

Radiation Therapy as a Rational Treatment for Fibroids, Menorrhagia, Ovarian Dysfunction, Inflammations, Fungus and Pyogenic Infections, etc LEONARD G CROSBY, M.D., Denver

The Place of Super-voltage X-ray in the Treatment of Malignancies CLYDE K EMERY, M.D., M.R.C.S., L.R.C.P., Pasadena, Calif

Discussion opened by FRANK B STEPHENSON, M.D., Denver

### CANCER INSTITUTE

The Medical School of the University of Wisconsin, at Madison, conducted a Cancer Institute from Sept 7 to 9, 1936. In the Section, "Cancer and Inheritance," were the following papers

"The Influence of Extrinsic Factors in the Development of Induced Tumors in Animals," by Dr Leiv Kreyberg, University of Oslo, Oslo, Norway

"The Influence of Intrinsic Factors in the Development of Tumors in Mice," by Dr C C Little, Director, Roscoe B Jackson, Laboratory of Cancer Research, Bar Harbor, Maine

"Familial Occurrence of Cancer," by Dr Madge T Macklin, Associate Professor of Histology and Embryology, University of Western Ontario, London, Ontario

"Hormones and the Development of Atypical Growths and Malignant Tumors," by Dr Edgar Allen, Professor of Anatomy and Chairman of Department, Yale University Medical School, New Haven, Conn

"Carcinogenic Substances in the Production of Tumors in Laboratory Animals," by Dr H B Andervont, biologist, U S Public Health Service, Boston

There were Round Table Discussions as follows

"Diagnostic Problems in the Recognition of Early Cancer," under the leadership of Dr S P Reimann, of the Lankenau Hospital and Graduate School of the University of Pennsylvania, by Dr Emil Novak, of Johns Hopkins Medical School, and by Professor Henri Coutard, of the Radium Institute, Paris

"Genetics—Inheritance and Cancer," by Dr Leiv Kreyberg, Dr C C Little, and Dr Madge T Macklin "Filterable Viruses and Cancer," under the leadership of Dr J B Murphy, Director of Cancer Research, Rockefeller Institute of Medical Research, New York City, by Professor B M Duggar, of the University of Wisconsin

"Surgery and Irradiation in the Treatment of Cancer," under the leadership of Professor Henri Coutard, by Dr G Failla and Dr Emil Novak

"Cytology of Malignant Neoplasms," under the leadership of Dr James Ewing, by Dr S P Reimann and Dr Warren H Lewis

"Etiology of Cancer," under the leadership of Dr H B Andervont, by Dr J B Murphy and Dr Edgar Allen

Dr James Ewing, of Cornell University Medical College and Memorial Hospital, New York City, broadcast a talk on "Cancer, a Public Health Problem," and Dr C C Little, speaking for the American Society for the Control of Cancer, on "A Program for the Control and Prevention of Cancer"

The following papers were read

"The Influence of Wave Length on the Biological Action of Radiation," by Dr Gioacchino Failla, physicist, Memorial Hospital, New York City

"The Reaction of Tissue Cells to Irradiation," by Professor Henri Coutard, Radium Institute, Paris

"Tissue Culture in the Study of Cancer," by Dr Warren H Lewis, Carnegie Institution of Washington, Baltimore

"The Biology of the Cancer Cell," by Dr S P Reimann, Philadelphia

## MIDSUMMER RADIOLOGICAL CONFERENCE, DENVER

This program was designed to better acquaint the entire medical profession with the uses of radiology in diagnosis and treatment. The Conference was sponsored by the Denver Radiological Club. The sessions took place Aug 5, 6, and 7, 1936. There was no registration fee. All meetings were held in the Venetian Gardens, Hotel Shirley-Savoy, Denver.

The following were guest speakers

EUGENE P. PENDERGRASS, M.D., F.A.C.R.  
Assistant Professor of Radiology, School of  
Medicine, University of Pennsylvania,  
Philadelphia

JOHN D. CAMP, M.D., F.A.C.R.  
Assistant Professor of Roentgenology, Mayo  
Foundation, University of Minnesota,  
Associate in Roentgenology, Mayo Clinic,  
Rochester, Minn.

J. M. MARTIN, M.D., F.A.C.R.  
Professor of Radiology, Baylor University,  
Dallas, Texas

CLYDE K. EMBRY, M.D., M.R.C.S., L.R.C.P.  
Assistant Professor of Radiology, California  
Institute of Technology, Pasadena, Calif.,  
Director of Radiation Therapy, Cedars of  
Lebanon Hospital, Hollywood, Calif.

The following were visiting speakers from  
the Radiological Club of Omaha

HOWARD B. HUNT, M.D., F.A.C.R.  
Associate Professor of Radiology, University  
of Nebraska Medical School, Omaha, Nebr.  
ANDERS P. OVERGAARD, M.D., F.A.C.R.  
Omaha, Nebr.

ALBERT F. TYLER, M.D., F.A.C.R.  
Attending Radiologist, St. Joseph and Im-  
manuel Hospitals, Omaha, Nebr.

T. TENNYSON HARRIS, M.D.  
Roentgenologist, Clarkson Hospital, Omaha,  
Nebr.

JAMES F. KELLY, M.D., F.A.C.R.  
Professor of Radiology, Creighton University  
School of Medicine, Omaha, Nebr.

EDWARD W. ROWE, M.D., F.A.C.R.  
Radiologist, Lincoln Clinic, Radiologist,  
Bryan Memorial Hospital, Lincoln, Nebr.

The following papers were presented

Recent Advances in Diagnostic Radiology  
ERNST A. SCHMIDT, M.D., Denver  
The Small Intestine EUGENE P. PENDER-  
GRASS, M.D., F.A.C.R., Philadelphia

The Gastro-intestinal Tract of Children  
JOHN S. BOUSLOG, M.D., Denver

Discussion opened by JOHN D. CAMP, M.D.,  
F.A.C.R., Rochester, Minn.

Osteoporosis and its Importance in Medical  
Diagnosis JOHN D. CAMP, M.D., F.A.C.R.,  
Rochester, Minn.

The Physician's Responsibility to the Cancer  
Patient J. M. MARTIN, M.D., F.A.C.R.,  
Dallas, Texas

Symposium on Gastro-intestinal Disease  
Arranged by the Radiological Club of Omaha,  
Chairman, HOWARD B. HUNT, M.D., F.A.C.R.,  
Omaha

Roentgen Diagnosis of Lesions of the  
Esophagus ANDERS P. OVERGAARD, M.D.,  
F.A.C.R., Omaha

The Value of the True Lateral Exam-  
ination of the Duodenum ALBERT F. TYLER,  
M.D., F.A.C.R., Omaha

X-ray Diagnosis of Lesions of the Colon  
T. TENNYSON HARRIS, M.D., Omaha

The Value of the Preliminary Film with  
out Opaque Media in the Diagnosis of Ab-  
dominal Conditions JAMES F. KELLY,  
M.D., F.A.C.R., Omaha

Radiography of the Biliary Tract, Before,  
During, and Following Operation HOWARD  
B. HUNT, M.D., F.A.C.R., Omaha

Malignancy Originating in the Small  
Bowel EDWARD W. ROWE, M.D., F.A.C.R.,  
Lincoln

Discussion opened by LORENZ W. FRANK,  
M.D., President of the Denver Internists'  
Club, Denver

Round Table Discussion of the Problems of  
Diagnostic Radiology, answered by our dis-  
tinguished guests. Chairman, W. W. WASSON,  
M.D., Denver

Symposium on Diagnostic Radiology S. B.  
CHILDS, M.D., presiding, Denver

Roentgenologic Findings in Patients with  
Sciatica and Low-back Pain JOHN D. CAMP,  
M.D., F.A.C.R., Rochester, Minn.

Discussion opened by HENRY W. WILCOX,  
M.D., President of the Orthopedic Club of  
Denver, Associate Professor of Orthopedic  
Surgery, University of Colorado Medical  
School, Denver

Heart Measurements ELIZABETH H.  
NEWCOMER, M.D., and NATHAN B. NEW-  
COMER, M.D., Denver

On the whole, the atlas presents a satisfactory group of cases to which reference could be made for the study of silicosis. Although it is narrow in its scope, referring only to stone workers, the excellence of the reproductions makes it a valuable medium for the study of the disease.

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"L'ANNEE ELECTRO-RADIOLOGIQUE DEUZIEME ANNEE" By MOREL-KAHN and collaborators. Second year (1934-1935). A volume of 266 pages, with 38 figures in the text. Published by Masson et Cie, 120 Boulevard St. Germain, Paris. Price, 40 francs.

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The second issue of "The Year in Electro-radiology," like the first, consists of articles by French authorities on those electro-radiologic subjects which are of greatest interest or importance to the French surgeon, internist, or general practitioner. As before, the book is in four parts, diagnostic radiology, general radiotherapy, electrology, and a report of various meetings. The material is well and briefly presented, but not too well illustrated. Each section is followed by a short bibliography in which one notices almost complete omission of non-French references. One wonders what may be the value of this sort of year book to the American radiologist.

"Filterable Viruses in Malignant Neoplasms," by Dr J B Murphy, New York City

At the joint meeting with the State Medical Society of Wisconsin the following papers were read "Biopsy in the Recognition and Treatment of Early Malignancy," by Dr James Ewing, "The Relation of Filterable Viruses to Malignant Neoplasms," by Dr J B Murphy, "The Effect of Bacterial Products on the Growth of Malignant Tumors," by Dr H B Andervont, "The Recognition and Treatment of Early Malignant Lesions of the Uterine Cervix," by Dr Emil Novak, "Treatment of Cancer of the Breast," by Professor Henri Coutard, "The Genetic and Constitutional Aspects of Spontaneous and Induced Tumors," by Dr Leiv Kreyberg, "Glandular Dysfunction and the Development of Malignant Tumors," by Dr Edgar Allen, "A Study of the Occurrence of Cancer in Different Individuals of the Same Family," by Dr Madge T Macklin

## BOOK REVIEWS

"RÖNTGENATLAS DER STAUBLUNGENERKRANKUNGEN DER RUHRBERGLEUTE," by VON DR G SCHULTE, Leiter der Röntgenabteilung am Knappschafts-Krankenhaus, Recklinghausen, unter Mitarbeit von Dr K Husten, Prosektor der Ruhr-Knappschaft am Knappschafts-Krankenhaus Essen-Steele. A volume of 141 pages, 153 illustrations. Published by Georg Thieme, Leipzig, 1936. Price, 23 40 RM

This is another of the valuable supplements issued by the "Fortschritte auf dem Gebiete der Röntgenstrahlen" and deals exclusively with silicosis as observed in the miners of the Ruhr district in Germany. The short introduction details the character of the material on which the atlas is based. There were about 115,000 workers in stone in this region in 1933. In the period of 1930-1933 there were 1,400 deaths from silicosis or its complications in Dortmund alone.

Schulte examined 10,867 workers between 1927 and 1935, while Husten contributes the data on the pathology of the disease, many of the cases having come to autopsy.

The discussion of etiology, pathology, and development of silicosis is in general in conformity with what has already been written on the subject. The authors believe a colloidal

suspension of the silica with the body fluids is the chief causative agent, although they admit the mechanical factor as well. Their classification is conventional although they seem to interpret cases with rather marked involvement as being in the first or second stage. Interesting curves of the relationship of the degree of involvement to the length of the time of exposure to dust are shown. There is a considerable discussion of predisposition to silicosis.

The authors emphasize strongly the importance of tuberculosis in producing rapid advance of the disease. They are convinced that silicosis predisposes to tuberculosis and record 70 per cent of the deaths as due to this complication.

The roentgen findings are described in some detail, with observations on differential diagnosis. The latter, however, is very weak and it is apparent that Schulte relies largely upon clinical evidence for eliminating other diseases. He emphasizes strongly, however, the relative absence of clinical signs in pure silicosis and the crucial importance of roentgen studies in diagnosis. The necessity for roentgen examination of the stone worker before employment and at frequent intervals afterward is repeatedly emphasized.

The atlas itself is divided into three parts containing a large number of very well produced plates, in many instances enlargements of a small portion of the lung-field are also shown. These are most instructive and the films as a whole are well selected and very illuminating.

In the first portion are shown normals, first, second, and third stage silicosis, silico-tuberculosis, one case with pneumothorax, one with lung gangrene. It is notable that the authors reproduce only one case of third stage silicosis in which tuberculosis was not present.

The second section concerns itself with the progress of the disease. Twenty six cases are illustrated with two or three plates of each at various intervals to show the changes in the roentgenogram. Particular emphasis here is placed upon the progressive nature of the disease even when exposure to dust has ceased, and the importance of tuberculosis in causing rapid progression.

The third section is most inadequate as a presentation of differential diagnosis. Only five cases are shown and these are fairly obvious. The more difficult problems in differential diagnosis are not touched upon.

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J N ANÉ M D , of New Orleans	DAVIS H PARDOLL M D of Chicago
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JOSEPH DAUKSYS, M D of Excelsior Springs, Mo	WILLIAM R STECHER, M D , of Easton, Pa
W H GILLENLINE M D of New Orleans	CHARLES G SUTHERLAND, M B (Tor ), of Rochester, Minn
J E HABBE, M D , of Milwaukee, Wisc	HENRY K TAYLOR, M D , of New York City
H W HEFKE, M D of Milwaukee, Wisc	
HANS A JARRE M D , of Detroit Mich	

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with a thick vault and large frontal sinuses The sella turcica was normal

The author differentiates this lesion from (1) acromegaly, (2) Paget's (3) von Recklinghausen's, (4) sclerosing osteitis of Albers-Schönberg, (5) melorheostosis (6) osteopetrosis (7) pneumo-chondro-dystrophy of Pierre Marie (8) infection, and (9) syphilis

Sections of the skin and palpebral tarsus were studied microscopically

The author believes that the lesion is a hyperplastic and degenerative disturbance of certain connective tissues (bones periosteum, palpebral tarsus, skin and subcutaneous tissues of face and extremities) due to an endocrine disturbance involving the parathyroid and pituitary glands

HENRY K. TAYLOR, M D

## THE BREAST (BENIGN)

The Roentgen Therapy of Tuberculosis of the Breast  
R. Glauner *Röntgenpraxis*, January, 1936 8, 38-42

Surgery has been and is the treatment of choice in tuberculosis of the breast The author has seen three proved cases in Grashy's Institute, in Cologne, and treated them with roentgen rays The technic consisted of small repeated doses (180 kv, filtered by 0.5 mm Cu) 150 r per treatment repeated at intervals of three weeks Between 180 and 900 r had to be given to achieve clinical cure The results of roentgen therapy in three reported cases was remarkably good The patients have been symptom free for three, twelve and sixteen months The author is of the opinion that a trial irradiation of tuberculosis of the breast is indicated

H. W. HEFKE, M D

## BREAST CANCER

The Radiological Management of Cancer of the Breast  
Richard Dresser and Valmore A. Pelletier  
*New England Jour Med*, April 9 1936, 214, 720-723

The authors analyze a series of 600 cases selected from representative cancer clinics In the first group they place the primarily operable cases A lateral view of the skull and dorsal spine and an anteroposterior view of the lumbar spine and pelvis including the upper ends of the femora and a postero-anterior view of the chest are considered as sufficient to rule out metastasis Surgery eradicates the cancer in 80 per cent of cases in this group Those who die succumb to metastases, consequently the authors deem it unwise to subject the entire group to the hazard of local radiation when not more than 20 per cent will be benefited Post-operative radiation is recommended in simple amputation of the breast without dissection of the axilla when gross or microscopic disease is present in the axillary nodes, and in women who have not passed the menopause

Sixty per cent of all cases belong in Group II (inoperable) Two hundred kilovolt peak roentgen rays with a filter of 0.5 mm copper, a total of about 3,400 r units are cross fired into the breast axilla, and supra-clavicular region over a period of from eight to ten

days Radiation is of little benefit when used on a metastasis, but it has an analgesic effect in cases with involvement of the spine

Group III covers post-operative recurrences Lesions of this type, when small respond well to a maximum of 1,800 r units given over a period of from a week to ten days

Group IV includes cancer of the breast in young women Radical mastectomy gave 15 per cent three-year cures in this group Cancer of the breast progresses with unusual rapidity during pregnancy and bears some relation to ovarian function Castration by means of a dose of 600 r to the front and back of the pelvis, using a 15 by 15 cm portal at a distance of 50 cm, produces a definite regression of bony metastasis in 30 per cent The danger of future pregnancy alone justifies this procedure, although results in a majority of cases have been encouraging

W. H. GILLENLINE, M D

## BRONCHIECTASIS

The Importance of Early Diagnosis in Bronchiectasis  
A Clinical and Roentgenologic Study of One Hundred Cases  
John T. Farrell, Jr *Jour Am Med Assn* Jan 11, 1936 106, 92-96

The author presents a clinical and roentgenologic study of 100 cases 52 males and 48 females Of the total number, 77 were 30 years of age or under when they first came under observation 22 were in the first decade 28 in the second and 27 in the third It was determined roentgenographically that in 41 patients the disease involved the left lung, in 23 it involved the right lung, and in 36 it was bilateral Eighteen patients had had symptoms for less than one year, 32 from one to five years 13 from six to ten years, 15 from eleven to twenty years and two for more than twenty years Seventeen patients had had the disease from infancy

In 45 cases the onset was secondary to some disease of the respiratory tract, in 12 cases the onset followed one of the diseases of childhood and the inhalation of a foreign body into the bronchus was the cause in four In two, x-ray evidence of bronchiectasis was associated with asthma

Ninety three cases were studied bronchoscopically and in 77 iodized oil was instilled for pneumonography Eighty four of these presented evidence of inflammatory changes in the bronchial tree in 15 tracheo-bronchitis, in 69 there was actual suppuration and pus was aspirated Nine patients had bronchoscopic evidence of occlusion in three the narrowing was due to extra-bronchial pressure and in the remainder it followed intrabronchial narrowing In three there was scar formation, in two cases an adenoma was found and in one a papilloma

Only 21 per cent of 66 patients whose sinuses were studied roentgenographically were normal, 24 per cent of these had marked disease, in most cases a pansinusitis

Roentgenographic and bronchoscopic examination are essential for early diagnosis Characteristic pneu-

## APPARATUS

A Dental Film holder with Centering Device  
Werner Rettig München med Wchnschr, April 24,  
1936, 83, 683-684

An ingenious and inexpensive device is described, for maintaining a dental film in position for intra oral exposures, and affording accurate and simplified direction of the x ray beam. The advantages are particularly evident in ill or nervous patients who are unable to co-operate in the ordinary method of holding the film packet in position by finger or bite blocks. Accurate visualization of the entire tooth is obtained regardless of anomalous configuration of maxilla or mandible or peculiarly directed teeth, with a minimum of distortion due to the bending of the film. Briefly the device consists of an adjustable forcep holding the film packet firmly with a metal rod affording the direction of angulation of the x ray tube. The patient holds the forcep firmly against the crown of the teeth to be examined.

WILLIAM R. STECHER, M.D.

## ARTERIOGRAPHY

Buerger's Disease, Arteriography, Arteriotomy  
L. Dejardin Bruxelles méd May 24, 1936, 16, 1138-1141

In a case of Buerger's disease, thorotrast was used to confirm the diagnosis and to establish the status of the circulation in the right forearm of a patient who had, two years previously, lost his left leg by amputation, for this same disease. Following arteriography the diseased artery was resected and the author reports relief of pain and a favorable thermal reaction of over a year's duration.

JOSEPH DAUKSIS, M.D.

## BLOOD CHANGES

The Effect of Roentgen ray Irradiation on Platelet Production in Patients with Essential Thrombocytopenic Purpura Hemorrhagica  
Stacy R. Mettler, Robert S. Stone and Katherine Purviance Am Jour Med Sci June, 1936 191, 794-807

The authors report their findings in seven cases, divided into three groups. The first group, acute recurring thrombocytopenia (four cases) showed a decided increase in the number of blood platelets beginning within from twenty-four to forty-eight hours after the institution of radiation therapy up to 500,000 within nine days. With the increase in the number of platelets there was an amelioration of symptoms. In one case there was a remission after seven months with recurrence of symptoms. A second series of treatments resulted in clinical improvement with an increase in the platelets to over 300,000.

The second group, chronic thrombocytopenia with recurring purpura (two cases), showed a temporary increase in the number of platelets which decreased shortly after the cessation of radiation therapy.

In the third group there was one case of an acute fulminating purpura which showed no response to radiation therapy. The patient died five days after the onset of symptoms.

The authors used the following technic: 200 kv, 15 ma, target skin distance 50 cm, filtration 0.2 mm tin, 0.25 mm copper, 2.0 mm aluminum. The radiation delivered 28.2 r per minute measured without back-scattering. The size of the field varied from 100 to 200 sq cm, depending upon the size of the patient as well as the size of the spleen.

In six cases the radiation was directed to the spleen using three portals and in one case, in which a splenectomy had been performed to the long bones. The patients received 200 r to each portal and only one portal was radiated daily. The total dosage delivered was 1,200 r.

When a second series of treatments was necessary 300 r were given daily, the total dosage up to 3,300 r.

HENRY K. TAYLOR, M.D.

## BONE DISEASES (DIAGNOSIS)

Hypertrophy of the Palpebral Tarsus, the Facial Integument, and the Extremities of the Limbs Associated with Widespread Osteo-periostosis. A New Syndrome.  
J. N. Roy Canadian Med Assn Jour, June, 1936, 34, 615-622

The author describes in detail the findings in an adult male who had been under observation for ten years. The patient presented:

- (1) Bilateral hypertrophy of the palpebral tarsus
- (2) Hypertrophy of the skin involving the face, eyelids and with a symmetrical hypertrophy of the lower third of the forearm and legs, wrists, hands, ankles, and feet
- (3) Atypical osteo-periostosis involving most of the bones of the skeleton

An osseous dystrophy with resorption and calcareous regeneration is manifested by an increased width of long bones particularly at the distal ends, the medullary canal is widened at the expense of the cortex, the compact bone presents a reticular appearance, the outline is irregular and nodular, osteophytic outgrowths in certain regions due to an ossifying periosteal hyperplasia which envelope the bone from one diarthrodial cartilage to the other including the extra-articular part of the epiphysis. This type of lesion involved the clavicles, the long bones of the upper and lower extremities, the metacarpals and metatarsals and phalanges of the hands and feet. The lower ends of the ulnas showed hypertrophy of the spongy bone. The scapulae presented irregularities in contour with destruction of trabecular structure. The iliac bones were not markedly affected—the shapes were not quite normal. The patellae were enlarged by numerous small exostoses, and presented a woolly appearance. The vertebral column was also involved—bodies deformed and presenting osteophytes. The ribs were normal. The skull showed an increase in the external diameters.

treatment Most of these cases had not lived for the three-year cure period Of 9 patients, 22 per cent who had been treated three years before were alive at the time of publication Three tables are appended giving condensed clinical data on all observed patients

ERNST A POHLE M D Ph D

A Technic for Roentgen Irradiation of Inaccessible Cancer of the Skin Howard H Ashbury *Am Jour Roentgenol and Rad Ther*, January, 1930, 35, 93-95

An impression of the lesion and surrounding areas is made in dental compound After the compound is hardened, sheet lead one sixteenth inch thick is fitted over the inner surface of it, thus producing a mask of the part under consideration A hole is then cut over the part to be treated and the mask strapped over the region The method is especially useful about the eye Detailed directions are incorporated in the paper

S M ATKINS, M D

Discussion on Short Distance Low Voltage X-ray Therapy H Chaoul, J M Woodburn Morison and J F Bromley *Proc Roy Soc. Med, Sect Radiology* May 1930, 29, 791-808

The paper opens with a discussion by the first-named author of a new development in x ray therapy which aims to be a substitute for the use of radium The technic is as follows

(1) Short focus skin distance (2 in ), (2) low voltage roentgen rays (60 kv ), (3) filtration (0.2 mm Cu), (4) small fields—surrounding normal tissue protected (5) fractional dose (total treatment from two to four weeks), (6) daily doses from 300 to 500 r, administered in from 2 to 4 min, (7) total dose from 5 000 to 10 000 r

The above is accomplished with a monopolar shock-proof x ray tube, measuring 2.5 X 15 centimeters

A depth dosage curve shows 56.2 per cent of the radiation at 0.5 cm, 43.7 per cent at 1 cm, 28.1 per cent at 2 cm, 18.7 per cent at 3 cm and 12.5 per cent at 4 cm (FSD 5 cm, field 12.56 sq cm, 60 kv 4 ma, 0.2 mm Cu measured in water)

This method has been employed in

(1) Skin carcinoma, 109 cases with 93.5 per cent success

(2) Lip carcinoma 26 cases with 88.5 per cent success

(3) Oral cavity carcinoma, 28 cases with 53.6 per cent success

(4) Carcinoma of glandular organs and the rectum, 45 cases with 64.4 per cent success

(5) Melanoblastoma, 12 cases with 83.3 per cent success

(6) Sarcoma 11 cases with 63.6 per cent success

Of the 231 cases six were under observation over four years 22 up to four years 32 up to three years 69 up to two years, and 59 up to one year Of the total group, 42 presented recurrences or were not healed and one patient died from another cause The author claims that 81 per cent of the cases under observation are

absolutely free of symptoms, and that this result surpasses the results obtainable from radium

This method permits treatment of all suitable cases at low cost and particularly where there are insufficient quantities of radium

The method is contra indicated in cases with large tumors or with many metastases, and in those cases which have received intensive x-ray or radium treatment

Professor J M Woodburn Morison claims that this method has a useful place in the treatment of malignant diseases, and should not be looked upon as a rival method of radiation therapy, but as an additional method suitable for accessible lesions His results have been similar to Professor Chaoul's and he has treated cases with epithelioma of the lips, floor of the mouth, alveolus, tongue, cheek, palate tonsil, and pharynx, recurrent nodules in cancer of the breast cancer of the rectum after operation—accessible cancers or cancers made accessible by operation

Dr J F Bromley has used the Chaoul tube in 70 cases with the following results healed, 22, improved, 37, worse, 9, died from cancer, one, died from other causes, one. He stresses the convenience with which it can be used for the localized ulcerating tumor, or localized excrescence in awkward situations as auricle, external auditory meatus, canthus of eye, ala of nose angle of mouth, etc

HENRY K TAYLOR M D

## CONTRAST MEDIA

Demonstration of the Seminal Vesicles on Roentgenograms by Iodipin Herbert Junghanns *Röntgenpraxis*, January 1930, 8, 21-24

Roentgenograms of the seminal vesicles after filling with iodized oil have been used occasionally for diagnostic purposes The author injected the vas during operation for sterilization. The normal roentgen appearance is described

H W HEFKE, M D

Visualization of the Cerebral Vessels by Direct Intracarotid Injection of Thorium Dioxide (Thorotrast) Julius Loman and Abraham Myerson *Am Jour Roentgenol and Rad Ther* February, 1930 35, 188-193

The diagnosis of certain cerebral conditions especially neoplasm and abnormalities of the vascular tree, can probably be definitely aided by intracranial arteriograms and phlebograms

Because of the difficulties of exposing and ligating the carotid artery into which the solution (thorotrast) is injected the authors have devised a technic whereby the artery is directly injected The region of the common carotid artery (level of cricoid cartilage) is infiltrated with novocaine In unco-operative patients, preliminary sedation with sodium amytal is recommended In the supine position, with the head hyper-

mographic changes are necessary for indisputable proof of the existence of the disease

CHARLES G SUTHERLAND, M B (Tor)

## CANCER (DIAGNOSIS)

Pulmonary Carcinoma and Pulmonary Abscess as Represented in Tomographic Roentgenograms H Chaoul and K Greineder Fortschr a d Geb d Röntgenstrahlen March, 1936, 53, 232-239

The most characteristic symptoms of pulmonary carcinoma are the central tumor nucleus, irregular narrowing of the bronchus, and concomitant atelectasis. Even density of the tumor nucleus and infiltration radiating into the periphery, as well as irregular central degeneration, may be recorded as further symptoms. Tomograms are unusually well suited to the demonstration of these symptoms.

Signs of abscess are not quite so typical and characteristic. The opacity is more mottled, the area of decay more rounded, oval, and smoother, often multilobular. Irregular narrowing of a bronchus never occurs in a draining abscess and peripheral atelectasis is most rare.

Tomography can be a valuable aid in the differentiation between pulmonary neoplasm and abscess formation.

H A JARRE, M D

The Roentgenologic Demonstration of Tumors Perforating into the Trachea E Saupe Röntgenpraxis, March, 1936 8, 156-159

A direct invasion of the trachea by neighboring carcinomas is not as often seen as displacement of the trachea by the tumor. Two cases are described, one, of an esophageal cancer protruding into the lumen of the trachea. The trachea was shown covered by barium which had been accidentally aspirated during the examination. In the second case a tumor mass (from a thyroid carcinoma) could be seen in the tracheal air space.

H W HEFKE, M D

Diagnostic Criteria of Colonic Cancer Curtice Rosser Jour Am Med Assn Jan 11 1936, 106, 109-111

The author reviewed 100 consecutive cases and noted a definite location coincidence in colonic tumors. More than half involved the descending colon and the sigmoid, one fourth the cecum and ascending colon and approximately one fifth the mid-colon.

Cancer of the cecum and ascending colon simulated appendicitis in more than two-thirds of the cases. Constipation was a feature of growths in the mid-colon. Constipation and colic characterized a majority of the neoplasms affecting the descending colon and sigmoid, about one fourth the patients of the series complained of continuous diarrhea.

Cancer of the rectosigmoid presented an accentuation of the symptoms seen in other parts of the left colon with a sharp rise in the number of patients who observed blood in the stool and a paradoxical decrease in the degree of anemia. Anemia, indigestion, localized pain not relieved by bowel movements, and palpable tumor were all highest in incidence in the right colon and decreased as the location approached the rectum.

Constipation, colic, and obstruction were the predominant features of colonic cancer in general.

Friedenwald, in the discussion stressed digital as well as proctoscopic examination, augmented by roentgen studies in diagnosis.

CHARLES G SUTHERLAND, M B (Tor)

## CANCER (THERAPY)

Roentgen Therapy in Malignancy Its Indications and Limitations Frank E Butler and Ivan M Woolley Northwest Med May 1936 35, 172-176

The authors comment on the fact that in treating malignancy they are treating a symptom of an obscure disease and that a factor in the outcome is the resistance of the patient to his or her particular malignancy. Prognosis depends upon (1) age of patient, (2) type of neoplasm, (3) location of lesion, (4) agent employed.

The value of roentgen therapy in malignancy is briefly discussed under the following topics: (1) Malignancies that may be expected to respond to irradiation without the aid of surgery, (2) Malignancies that are best treated by a combination of surgery and irradiation, (3) The inoperable malignancies, (4) Malignancies which fail to give worth while response to roentgen therapy, (5) Metastatic malignancy, (6) Recurrent malignancy following surgery.

HENRY K TAYLOR M D

The Lympho-epithelial Carcinoma R Baumann Schenker Strahlentherapie, 1936, 55, 369

The author analyzed in detail the 23 cases of true lympho-epithelial carcinoma seen in 1928-1935 at the Schinz Institute in Zürich. There were 17 carcinomas in the epipharynx, three in the mesopharynx, and two in the hypopharynx, one was located in the trachea and probably started from a residual thymus gland. The differential diagnosis was sometimes difficult because lymphosarcoma, transitional-cell carcinoma and endothelioma may present similar histologic pictures. Radiation therapy is, according to the author, the method of choice. Technic: 180 kv, 3 mm Al or 0.5 mm Cu if single massive doses were applied. Since 1929 the protracted fractional dose method (Coutard) has been used, the original filter of 1 mm Cu + 1 mm Al was changed in 1933 to a Thoracal filter and in 1934 to 2 mm Cu + 1 mm Al. Residual masses found after roentgen therapy were treated by applications of radium as described by Berven.

Of the 23 cases 18 were alive and 14 free from symptoms in December 1935, i.e. six months after the last

This study is based on an analysis of 193 cases available. Of 6 650 individuals roentgenographed, there were 229 of these cases, of which 225 were females

S M ATKINS M D

## DERMATITIS

The Surgical Treatment of Chronic Radiation Dermatitis Stuart Gordon Canadian Med Assn Jour, June 1936, 34, 622-624

The author quotes Porter's clinical grouping of patients with radiation dermatitis

1 Those who have received a single therapeutic or diagnostic dose (may be due to individual idiosyncrasy, radiation to an area in which vascular damage is present, or intentional heavy dosage)

2 Those who have received repeated doses at intervals

3 Personnel administering the treatment and who have suffered injury

There are two clinical types the acute and chronic ulceration. The acute one develops rapidly after exposure—an irregular shallow ulcer which is due to actual cell death and if small may respond to local treatment. The chronic one which may appear as late as twenty years following exposure, first presents a brownish pigmentation in the radiated area which fades in a year—telangiectases appear in the thin dry, hairless skin—dark areas of thrombosis appear—the corium gradually thickens (itching and burning of involved area)—hyperkeratoses develop—tiny cracks appear in the skin and eventually ulceration supervenes which may undergo malignant changes

The surgical treatment of the chronic lesion is directed to (1) relief of symptoms (2) repair of deformity, and (3) removal of danger of malignant change. This is accomplished by adequate excision followed by some type of skin grafting

HENRY K TAYLOR M D

## THE ESOPHAGUS

A Method of Roentgen Diagnosis of Non-opaque Foreign Bodies in the Esophagus Wendell G Scott and Sherwood Moore Jour Am Med Assn March 14 1936 106, 906-908

The most common foreign body of this type is a small piece of bone from a fowl or fish. These bones are usually fragments of the sternum or rib of a chicken, are incompletely ossified and calcified the calcium content has been further removed by cooking and they are relatively non-opaque to x rays. Other foreign bodies are buttons many of which are transparent to x rays or a firm bolus of food especially meat the latter sometimes halted by inherent lesions such as stricture or carcinoma, or extrinsic pressure from mediastinal tumor aneurysm enlarged thyroid hyoid or left auricle

The customary site of lodgment is at the level of the suprasternal notch, as it is normally the narrowest segment of the esophagus. Lesser constrictions occur at the introitus at the level of the crossing of the left bronchus, and at the diaphragmatic pinchcock.

Films and fluoroscopic studies include the nasopharynx and the stomach. Anteroposterior and lateral views of the neck are made before resorting to the use of opaque media. Fluoroscopic visualization, using a thick suspension of barium sulphate in water, follows, with careful search for deviation or division of the stream or filling defect in the esophagus. When the patient has swallowed the barium careful search is made for evidence of a residuum of it clinging to a foreign body. Failing in these examinations, the patient stands in front of the regular cassette changer and drinks a thin watery solution of barium through a glass tube in small rapid swallows in an effort to maintain a continuous stream down the esophagus. Exposures are made in both the anteroposterior and right anterior oblique positions the latter being preferred to a lateral view. The barium mixture coats the esophageal walls and in meeting a foreign body, produces a constant filling defect. In addition, it coats the foreign body which is demonstrated as a constant collection of opaque material within the lumen of the esophagus.

Esophagoscopy should be performed as soon as possible after the diagnosis

CHARLES G SUTHERLAND, M B (Tor)

## FISTULAS

Radiation Therapy of Anorectal Fistula. Delherm and Devois Strahlentherapie, 1936 55, 137

The authors recommend roentgen rays in the treatment of anorectal fistula. Technique 120 kv 3-8 mm Al, 250 r once or twice per week. After from six to eight sittings a mild erythema usually appears. If necessary a second series can be given after an interval of from three to four weeks.

An attempt was made to improve the results by the use of a secondary irradiator (copper), this was, however not very successful. Injection of a quinine-urea solution into the fistula seems to be of benefit and acts as an adjunct to radiation therapy.

ERNST A POHLE M D Ph D

Carcinomatous Change in Fistula Hans Hellner München med Wchnschr April 24 1936 83, 689 690

In the case of a fistula resultant of osteomyelitis of chronic pyogenic tuberculous, or syphilitic origin, the chronic irritation may eventuate into carcinoma along the tract. Roentgenograms may show evidence of such as sudden unexplained and rapidly progressing osteoclasia in a hitherto sclerotic osteomyelitic process. When the above is present in addition to increased fetid discharge tissue should be obtained for section and if confirmed as carcinomatous radical amputation should be instituted.

WILLIAM R STECHER, M D

extended thus fixing the artery, and the fingers placed as a guide over the line of maximum impact the puncture is made by a  $1\frac{1}{2}$  in, No 18-19 gauge needle connected by a three-way stopcock to a 20 c c syringe. The stopcock is in turn connected to a glass tube and stiff rubber tubing, both of which are filled with citrate and finally to an aneroid Tyco's manometer. Only when there are free and wide oscillations of the manometric needle and drop of the pressure with compression of the artery below the puncture to be followed by immediate return to normal with removal of the compression is the syringe disconnected and replaced by one containing thorotrast.

As an assistant compresses either the homolateral carotid at the root of the neck or still better, both internal jugulars over the sternomastoid muscles the thorotrast is injected rapidly. Lateral views of the skull are taken immediately after injection of 10 c c. A fair phlebogram may be made three to four seconds later. No harm need be expected from these injections, even when there is some spilling into the tissues including the brain.

S M ATKINS, M D

Thorium Hydroxide Sols as Opaque Media in Roentgenography. Thomas O Menees and J D Miller. *Am Jour Roentgenol and Rad Ther* February, 1936 35, 194-199.

Thorium hydroxide sols form an opaque coagulum with proteins in an alkaline medium. The coagulum forms a coating on the wall of a viscus thus outlining the mucous membrane in relief. The medium does not coagulate in an acid medium or with secretions poor in proteins thus making them unsuitable for the stomach, nasal accessory sinuses, esophagus, bladder, or urethra. Its chief use is in the uterus, sinus tracts, and in fistulae.

In the uterus the mucosal pattern is demonstrated as well as such conditions as hyperplasia, hypoplasia, mucous polyp, endometrioma, carcinoma, submucous and intramural myoma. Pregnancy and pelvic inflammation are the only contra-indications to the use of this method. The injection is made with the cervical canal wide open.

S M ATKINS, M D

## THE CRANIUM

Oxycephaly with the Report of Two Cases in a Brother and Sister. David L Klein and A E Childe. *Canadian Med Assn Jour* April 1936 34, 397-399.

The authors describe two cases of oxycephaly and present x-rays showing exaggerated convolutionary markings, thinness of the vault of the skull, upward projections at the bregma, the outward bulging of the temporal region, and shallow orbital cavities.

W H GILLENTE, M D

This condition refers to a hyperostosis of the skull, apparently due to faulty metabolism and accompanied by a distinctive clinical picture. Another group characterized by localized thinning of the skull which probably also belongs under this heading is not yet proven.

The hyperostoses are of two orders: one involving the compact bone of the inner table with later invasion of the diploë, the other being limited to the diploë. Again this condition is divided into four types based on their location: namely, hyperostosis frontalis interna, hyperostosis calvariae diffusa, hyperostosis fronto-parietalis, and nebula frontalis. All are bilaterally symmetrical and all four may be present in one individual.

*Hyperostosis Frontalis Interna* shows either nodular or sessile very dense cancellous bone deposited on the inner table of the squama frontalis and varying from that which is barely detectable to masses more than 1 cm in thickness. The intracranial aspect has an outline wavy in the nodular and regular in the sessile forms, and is smooth. There is no change of the skull externally. No progression or diminution has been noted in those individuals examined over a period of years.

*Nebula Frontalis* is seen as a triangular or ovoid area of density and thickness in the squama frontalis with a broad base in the sagittal plane and owing to its involvement of the diploë only can be demonstrated in the lateral view only. Its variations are many and it does progress.

*Hyperostosis Calvariae Diffusa* shows a general even increase in the volume and density of the diploë of the vault of the skull. Because of the density the roentgenogram lacks detail, the vascular grooves are deepened, the skull is enlarged internally but not externally.

*Hyperostosis Fronto-parietalis* is also diploë and roentgenologically the change is like the calvariae diffusa and nebula frontalis except that the maximum thickening is at the central points of the squama of the frontal and parietal bones producing thus an even gentle grooving at the coronal and sagittal sutures. This is the most indefinite and infrequent type.

All these may be due to an excess of calcium in the organism and clinically the symptom-complex is as striking as the roentgen findings. For with a few exceptions the patients had neurological and neuropsychiatric symptoms. The syndrome was a combination more or less constant of headache, obesity of the rhizomelic type, enlarged breast in the female, easy fatigue, muscular weakness, nervousness, tendency to worry and depression, dimness of vision, occasionally diplopia, epileptiform seizures, impairment of memory and even definite cranial nerve involvement. Overgrowth of facial hair may occur in the female. The nerve and muscular weakness resembles in some respects chronic intoxications.

Treatment is as yet not definite but in cases in which metabolism can be shown to be at fault it should be combated and in cases in which pressure on vital areas is present the bone should be removed.

Metabolic Craniopathy. Sherwood Moore. *Am Jour Roentgenol and Rad Ther* January 1936 35, 30-39.

not seen until they are far advanced. The clinical histories of gastric carcinoma may be divided into two groups, as follows: (1) those in which the symptoms have arisen recently and suddenly in previously healthy individuals, and (2) those in which there has been dyspeptic trouble over a long period of time. It is estimated that there are from five to six patients in the first group for every one in the second. Statistics also show that by the time the patients reach x-ray examination and surgery, 50 per cent are inoperable. While the other 50 per cent are operated on, in only one-half of these cases is resection of the lesion justifiable. It is of interest likewise that in the group in which symptoms appear suddenly an average interval of from eight to ten months exists between the onset and the x-ray examination.

In the primary stages of carcinomatous involvement there may be nothing beyond narrowly limited infiltration of the stomach wall by cancer cells with localized induration. During peristaltic action this area tends to remain fixed in shape. Throughout the progress of an infiltrating, scirrhus type of carcinoma there may be no irregular projections of the malignant tissue into the lumen of the stomach, and therefore none of the classical "filling defects."

The mucosal pattern visualized by a small quantity of suitable opaque medium is considered of value in the study of the gastric lumen. Around the more or less acute simple ulcer the inflamed mucosa becomes greatly swollen. As the swelling subsides so does the depth of the ulcer crater. In contradistinction to the above is the local irregular, heaped up margin of neoplastic tissue around the malignant ulcer. Such a rugal study reveals the disappearance of the folds over an area of infiltration in early scirrhus malignancy and the abrupt discontinuity of the mucosal folds at the edges of a fungating mass.

The cardiac end of the stomach is difficult to examine as the rugal folds are coarse and complicated and this portion of the stomach cannot be palpated. Clinical symptoms may be slight if there is no involvement of the lower esophagus. However Stewart and Illick have enumerated eleven diagnostic radiological signs of cancer of the fundus.

The radiological examination of the normal pyloric antrum shows the terminal line parallel to the base of the duodenal bulb. Localized irregularities in the form of the prepyloric gastric lumen, general narrowing of this segment, widening of the sphincteric zone with loss of the normal parallelism are significant findings.

The significance of deformation of the duodenal bulb or first portion of the duodenum is problematical. In the presence of acute symptoms of ulceration a deformity of this portion of the duodenum is considered as evidence of ulceration even though no crater is demonstrated. On the other hand, after the disappearance of symptoms the deformity which is still visible is interpreted as being due to cicatricial tissue. The author does not believe it justifiable to consider deformation as indicative of both conditions. The demonstration of the crater, however, is practically

diagnostic of ulceration. The discovery of the "irritable cap," as manifested by intrinsic peristaltic activity, failure to retain the food received from the stomach and the various degrees of spastic deformation may aid in the diagnosis.

Because of practical and economic reasons the author suggests two types of examination in gastro-intestinal cases. The first of these consists of the standard or routine examination which should be sufficient but not over-elaborate. The second type of examination comprises various special techniques as examination of the esophagus by all available methods, study of the rugal pattern, investigations of the small intestine and colon. All patients should be thoroughly examined by the standard method. All cases presenting the slightest evidence of pathology, even of a questionable nature, at the routine examination and all cases with definite clinical findings of pathology and negative routine examinations, are to be recalled for further roentgen examination by means of the special techniques.

J. N. ANÉ, M.D.

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Dystopy of the Colon after Phrenic Exeresis. Burkhard Kommerell. *Röntgenpraxis*, February 1936, 8, 102-103.

In a patient who had had a phrenicectomy eight years previous to examination, a roentgenogram of the chest showed a high diaphragm on the right and air under the diaphragm which appeared to be in the colon. A colonic enema showed an interposition of the right side of the transverse colon between the liver and the right diaphragm. Symptoms were not complained of. The author believes that the displacement of the colon is due to the previous operation.

HANS W. HEFKE, M.D.

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Gastric Diverticulum Below the Cardia, Problems of Radiologic Diagnosis. Jean Charles Roux and Henri Bécère. *Arch. d. Mal. de l'App. Digestif*, May, 1936, 26, 593-596.

The authors report a case of gastric diverticulum which was first seen upon routine examination in 1927. It devolved upon them nine years later to examine the same patient and to their surprise no evidence of diverticulum could be made out, even after a prolonged and varied examination. They hazard the opinion that there was probably inflammatory swelling of the narrow entrance to the diverticulum which prevented the ingress of barium and recalling a number of cases in which similar experiences were encountered, deem it imprudent to consider that a previously shown diverticulum does not exist because it is not visualized at a later examination.

Though gastric diverticula have been considered rather rare the authors call attention to the fact that during the last three months a large number of cases have been reported to the Gastro-enterological Society



## GASTRO-INTESTINAL TRACT (DIAGNOSIS)

What Does the Finding of Fluid Levels on Flat Films of the Abdomen Mean? A Contribution to the Differential Diagnosis of Intestinal Obstruction Bernhard Becker *Röntgenpraxis*, March, 1936, 8, 145-156

The importance of fluid levels on abdominal films, taken in the standing position or lying on the side is recognized by radiologists and surgeons. This roentgenologic symptom does not mean intestinal obstruction in every case and critical consideration of other diseases which may cause it is necessary.

Fluid levels may be seen outside the intestinal tract, for instance, in gas-containing peritoneal pockets (peritonitis, perforated ulcer, etc.). Air pockets may be seen post-operatively. The absence of Kerkring's folds or colonic haustra around these gas pockets indicates their extra-intestinal position.

Normally no fluid levels are seen in the small intestine of adults, except occasionally a gas bubble in the duodenal cap or in duodenal or jejunal diverticula. In infants, gas and fluid levels may be seen normally. Fluid levels in the colon especially cecum and flexures are fairly often demonstrable in healthy individuals. Acute infectious diseases of the intestines (enteritis typhoid fever, dysentery) may cause formation of fluid levels and gas in the small intestines. Very rarely a pneumonia or severe decompensation of the heart might lead to similar findings. Opiates are known to cause a dilatation of the small intestines, and fluid levels found in patients after administration of morphine may be of no diagnostic significance at all. It is possible to show fluid levels in the colon and the distal ileum for a few hours after cleansing enemas. In questionable cases a barium enema which is almost always possible might be used to great advantage.

H. W. HEFKE, M.D.

Graded Compression in the Exploration of the Digestive Mucosa René Gilbert and Leon Babianitz *Arch. d. Mal. de l'App. Digestif*, May, 1936, 26, 556-575

Exploration of the gastro-intestinal mucosa with the aid of graded and localized compression is a supplementary form of examination used, not as a routine measure but as indications arise particularly when the clinical story appears clear-cut and routine examinations are fruitless. Good results are obtained and a niche is readily demonstrated particularly in small ulcers of the lesser curvature and those of the posterior wall. In the presence of retention particularly good results are obtained. Enlarged rugal folds as in hypertrophic gastritis, and diminished folds as seen in pernicious anemia are very readily made out. In the duodenum the 'niche de face' is easily demonstrated but in the jejunum poor results are obtained principally because of the superimposition of various loops. In the terminal ileum and in the colon the mucosa is also well shown. Because of the ribs it is difficult to use

compression at either colonic flexure or at the cardiac portion of the stomach.

The authors do not advise the use of compression following recent hemorrhage and in patients with sensitive abdomens and in the feeble and weak. In the presence of occult hemorrhage, compression is used cautiously and no accidents have been experienced in these cases. Excessive pressure is to be avoided not only because of the possibility of harming the patient but also because it leads to error by obliterating the normal mucosal markings.

The observations reported result from an experience of two years in the study of the gastro-intestinal mucosa with the aid of localized and graded compression.

JOSEPH DAUXSIS, M.D.

The Effect of Foodstuffs on the Emptying of the Normal and Operated Stomach and the Small Intestinal Pattern I. S. Raydon, E. P. Pendergrass, C. G. Johnston and P. J. Hodes *Am. Jour. Roentgenol. and Rad. Ther.* March, 1936, 35, 306-315

The type of meal influences strongly the small intestinal pattern as seen roentgenologically and the progress of the meal through the gastro-intestinal tract in the normal as well as the pathological case. The writers' investigation indicates that the water and barium mixture exerts no specific influence on the gastric emptying time and this type of meal is, therefore, recommended as the standard one for the determination of pathological lesions of the gastro-intestinal tract. The variation in the appearance of the small intestinal pattern with different types of meals must be recognized by roentgenologists if they would correctly evaluate small bowel abnormalities.

The necessity for caution in the roentgenologic consideration of disturbances in the gastric motility of the recently operated stomachs is emphasized.

J. E. HABBE, M.D.

Radiological Examination of Stomach and Duodenum with Special Reference to the Early Diagnosis of Cancer K. Stuart Cross *British Med. Jour.* Feb. 22, 1936, No. 3920, 353-357

The author emphasizes the importance of consultation between the internist and the radiologist in order that the latter may be fully acquainted with all facts regarding the patient's clinical findings. The radiologist should be a physician and a pathologist with the ability to recognize the radiological manifestation of macroscopic disease. The necessity and value of re-examinations in all doubtful cases cannot be over-emphasized. It should always be remembered that the essentials of efficient radiology are the knowledge, experience and clinical acumen of the radiologist rather than impressive x-ray apparatus.

Gastric carcinoma is best detected by means of the roentgen ray. It is unfortunate that so many cases are

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## HEPATOSPLENOGRAPHY WITH STABILIZED THORIUM DIOXIDE SOL

A FOLLOW-UP STUDY OF 200 PATIENTS EXAMINED OVER A PERIOD OF FIVE YEARS<sup>1</sup>

By WALLACE M. YATER, M.D., LAURENCE S. OTELL, M.D.,<sup>2</sup>  
and HUGH H. HUSSEY, M.D., Washington, D. C.

From the Georgetown University School of Medicine, the Gallinger Municipal Hospital, and the Radiologic Clinic of Doctors Groover, Christie, and Merritt

SINCE 1928, when Oka (1 and 2), in Tokio, and soon thereafter Radt (3 and 4), in Berlin, began work to develop a method for demonstrating the morbid anatomy of the liver and spleen on x-ray plates by means of thorium preparations injected into the blood stream, several groups of investigators have had a moderately large experience with this procedure. However, those who have used this method of diagnosis have been relatively few due to the facts that thorium dioxide, the substance adopted, possesses some radioactivity and is eliminated from the body with extreme slowness. In 1932, the Council on Pharmacy and Chemistry of the American Medical Association (5) reported unfavorably on the intravenous use of thorium dioxide and urged great caution in its use in man. One of the points stressed in this report was that there is a possibility that the thorium dioxide in the tissues might be converted as time went on, in part at least, to some more radio-active substance, such as mesothorium, and that radium poisoning possibly would result.

The purpose of this report is to review

the experience of our use with this method of diagnosis, which has covered a period of nearly five years and which has involved considerably more than 200 patients. The preparation we have used in all our cases has been a stabilized colloidal solution of thorium dioxide containing approximately 22 per cent of metal by volume.<sup>3</sup> This substance, when injected into the blood stream, is rapidly removed and engulfed by the reticulo-endothelial cells throughout the body. These cells, being most numerous in the liver and spleen, allow these organs to be demonstrated on x-ray films, because thorium, a metal of high atomic weight, is radiopaque. The average dose employed by us has been 75 c.c., being given usually in divided doses of 25 c.c. on successive days. This amount of the solution contains a quantity of thorium dioxide equivalent in alpha-ray activity to from 15 to 30 micrograms of radium. The beta-ray and gamma-ray activity is probably insignificant.

Even after a period of five years x-ray films demonstrate that there is still a large amount of the metal present in the body, but there is also definite evidence of some

<sup>1</sup> Read before the Section on Practice of Medicine at the American Medical Association Session, Kansas City, Mo. May 13, 1936.

<sup>2</sup> Dr. Otell died July 27, 1936.

<sup>3</sup> The preparation employed was thorotrast manufactured by the Heyden Chemical Corporation of New York.

of Paris and believe such occur more frequently than is thought, being found if searched for systematically

Attention is also called to the fact that the presence of a gastric diverticulum does not always solve the clinical problem, inasmuch as 30 per cent of these are accompanied by associated lesions such as gastric and duodenal ulcers as well as different types of tumors

JOSEPH DAUKSIS, M D

## GENITO-URINARY TRACT (DIAGNOSIS)

Encrustation of the Bladder as a Result of Alkaline Cystitis H G Letcher and N M Matheson Brit J Surg, April, 1936, 23, 716-720

The authors report a case of alkaline cystitis followed by encrustation of the bladder. The onset of the attack was in the early months of pregnancy. The bladder wall was outlined in skiagrams and almost the entire bladder was affected. Although the voided urine was strongly alkaline specimens secured by ureteric catheterization were acid. In the authors' case repeated examinations failed to isolate the *B. proteus ammoniae* from the urine. The remarkable benefit which followed lavage with acid solutions appears to be unusual.

DAVIS H PARDOLL, M D

Unilateral Renal Agenesis Temple Ainsworth Southern Med Jour, June, 1936, 29, 619-622

The author recommends the classification of renal agenesis as presented by Gutierrez in order to avoid confusion in the future. The incidence, embryology, clinical importance, signs, symptoms, and diagnosis are reviewed. Two additional cases of renal agenesis are supplemented by the writer. In Case 1, the importance of a careful urologic and urographic examination, even in an emergency operation and lacerated kidney is illustrated. In Case 2 the finding of a rudimentary structure microscopically composed of glomeruli and tubules with no excretory function and a non patent ureter, is typical of a congenital aplastic kidney. In both of the reported cases there was an associated congenital anomaly. An abstract of the discussion appears along with the article.

DAVIS H PARDOLL, M D

Kidney Function in Acute Calculous Obstruction of the Ureter. Some Observations of Kidney and Ureter Function in Acute Calculous Obstruction of the Ureter Based on Excretory Urography Leslie F Wilcox Am Jour Roentgenol and Rad Ther November 1935, 34, 596-605

In acute calculous obstruction of the ureter certain characteristic findings are evident in excretory urography. The urographic finding of three clinical cases together with experimental studies in rabbits indicate

that there is retardation of urinary secretion from the kidney on the affected side and no pyelogram or ureterogram is obtainable, however the kidney function does not cease as there is increased density of the kidney shadow. As the pain and obstruction are relieved by the administration of morphine the secretory function promptly returns to a normal level so that from 30 to 60 minutes after the injection of the dye there may be obtained for the first time a good pyelogram and ureterogram down to the level of the calculus. Pain in acute calculous obstruction is attributable to increased pressure and distention of the ureter, kidney pelvis and capsule and not to the presence of the calculus in the ureter producing spasm.

In conducting an intravenous urographic examination therefore particularly in the presence of a suspected calculous obstruction the study must be continued late into the period of complete excretion of the dye if all valuable information is to be obtained.

J E HABBE, M D

Diagnosis of Traumatic Lesions of the Urinary Tract with Special Reference to the Value of Excretory Urography Fred O Coe Am Jour Roentgenol and Rad Ther February, 1936, 35, 218-225

Trauma of the organs of the urinary tract is now more common than formerly owing to automobile and industrial accidents and to strenuous sports.

Excretory urography affords a safe rapid and very accurate method of diagnosis of traumatic lesions of the urinary tract. In all such cases it is the method of choice and in children is often the only method practicable. There are no increased hazards of infection and practically no reports of untoward reactions. In some the diagnosis is not conclusive owing to complete cessation of the kidney function or failure to fill due to back pressure from a blood clot in the pelvis. At times it is necessary to wait as long as two hours for a kidney image.

The roentgen finding from the flat films may be presumptive such as fracture of the lower ribs adjacent to the kidney, fracture of the transverse processes or obliteration of the psoas muscle and kidney on the affected side. Retrograde pyelography should be avoided due to the hazard of infection plus the added shock of instrumentation. The clinical findings must also be considered as well as the type of lesion. Both of these are discussed.

S M ATKINS, M D

Adenocarcinoma of the Jejunum Miklos Weisz Röntgenpraxis January, 1936 8, 28-31

An incomplete small intestinal obstruction is often the first x ray symptom of a cancer of the small intestine. That symptom is not consistently present. The actual demonstration of the filling defect by repeated examinations should be possible in most cases.

H W HEFKE, M D

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the experience of our use with this method of diagnosis, which has covered a period of nearly five years and which has involved considerably more than 200 patients. The preparation we have used in all our cases has been a stabilized colloidal solution of thorium dioxide containing approximately 22 per cent of metal by volume.<sup>3</sup> This substance, when injected into the blood stream, is rapidly removed and engulfed by the reticulo-endothelial cells throughout the body. These cells, being most numerous in the liver and spleen, allow these organs to be demonstrated on x-ray films, because thorium, a metal of high atomic weight, is radiopaque. The average dose employed by us has been 75 c c, being given usually in divided doses of 25 c c on successive days. This amount of the solution contains a quantity of thorium dioxide equivalent in alpha-ray activity to from 15 to 30 micrograms of radium. The beta-ray and gamma-ray activity is probably insignificant.

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mobilization of it from the original reticulo-endothelial cells in which it was deposited.

Immediate reactions due to the injection of the solution in the amount used have been extremely few and on the whole extremely mild. In the last three years we have not noted any immediate reactions that were apparent to ordinary observation. Some patients have received as much as 100 c c, and one was given this entire amount within one hour without an appreciable reaction. A number of others have had 50 c c injected at one sitting without reactions.

Solution of thorium dioxide is also of value in other fields of roentgenology. It is the best medium for arteriography, and it is satisfactory for ventriculography and retrograde pyelography. Our previous reports (6, 7, and 8) and those of others who have had considerable experience with hepatosplenography, have demonstrated its usefulness in the diagnosis of intra-abdominal disease. In the report of our clinical experience with our first 80 patients (7), we concluded with the statement that "greater experience with it will reveal its true value, its finer points, and its limitations." We feel that we have progressed considerably in the direction of knowing these facts.

#### TECHNIC OF HEPATOSPLENOGRAPHY

Until recently we have employed an average of 75 c c of the stabilized solution of thorium dioxide in adults of average size, and have reduced the total dosage in children roughly in proportion to the weight. We have experimented with smaller doses to determine the smallest amount which would be satisfactory for good detail of the structure of the liver and spleen in the films. We have come to the conclusion that perhaps a little less than the total dosage previously employed may be satisfactory, and we are now using 0.5 c c for each pound of body weight. One-third of the total dosage is usually injected intravenously on each of three successive days, and on the fourth day or any time

thereafter the films are made.<sup>4</sup> No particular preparation of the patient is necessary except that it is advisable to have the intestinal tract as free of gas as possible when the x-ray exposures are made.

Films are taken with the patient in the prone position on the Potter-Bucky diaphragm, the tube being centered over the ensiform cartilage. The following technic is quite satisfactory: 67 kilovolts peak at 30 milliamperes for 6 seconds at 30 inches distance. Eastman or Du Pont films are satisfactory. No compression is made. A more comprehensive idea of the structural characteristics of the liver and spleen is obtained by making several exposures within a range of 10 kilovolts of this dosage. In larger individuals the film should be placed transversely in order to include the entire liver and spleen. Dilution of the solution is unnecessary, and the preparation may be injected at about room temperature. The solution is opalescent, odorless, and has the consistency of heavy oil.

#### APPEARANCE AND SIZE OF THE NORMAL LIVER AND SPLEEN

In good films made within a year or two after the injection of the solution, the liver casts a relatively homogeneous shadow of approximately the same density as the spine (Fig 1). Occasionally blood vessels in the liver are seen as dark branching lines. The spleen normally has a density slightly less than that of the liver and about the same as that of the ribs. The splenic shadow is usually homogeneous but occasionally is uniformly mottled. So far as determination of the size of the liver and spleen is concerned, this can be done only roughly, especially in comparative progress films. We have noted considerable variation in the size of the liver shadow on films taken within a short period of each other.

<sup>4</sup> If haste is necessary, the entire amount of thorotrast may be injected at one time and the films made as soon as one hour afterward. Experiments made by us show that the liver and spleen contain thorotrast as early as 15 minutes after injection. At the end of two hours good detail is present and after four hours no further improvement in detail is apparent. If the amount of thorotrast injected does not allow good detail, an additional 15 to 25 c c is injected.



Fig 1

Fig 1 Normal hepatosplenogram



Fig 2

Fig 2 Cirrhosis of the liver. Film made more than two years after injection of stabilized thorium dioxide sol. The liver is granular, the left lobe is enlarged. Opaque masses seen on each side of the spine are lymph nodes containing mobilized thorium dioxide (Case 6)

Apparently there is no absolutely normal size that may be used as a standard, although our average normal "length" of the liver shadow, as measured from the highest point of the upper border to the lowest point of the tip of the right lobe, varied between 18 and 22 cm, and the average "oblique measurement," from the upper to the lower border in a direction giving the maximum measurement of the approximate thickness of the liver, varied between 10 and 14 centimeters. These are approximately the figures previously established by Pfahler (9). Normally, the right lobe of the liver constitutes most of the liver shadow, the left lobe being practically invisible and obscured by the spine. Ascites causes the liver to appear smaller than it actually is. The splenic shadow normally covers an area of two intercostal spaces, extending usually from the ninth to the eleventh rib. It is often less distinct than that of the liver because of the constant presence of gas in the stomach and colon. Our experience has shown us, therefore, that it is only within certain limits that deviations in size from the nor-

mal and from time to time are reliable. Even the shape of the liver and spleen may vary in films taken at different times. Considerable experience is therefore necessary before one learns not to attach too much importance to moderate variations in shape and size.

#### USES OF HEPATOSPLENOGRAPHY

While much information can often be obtained by the study of films alone, it is only proper that all of the clinical findings should be taken into consideration at the same time. This rule, of course, applies to roentgenology in general.

In a previous article (8), we concluded that the method is of value as follows:

- 1 In determining the nature of a mass in the upper part of the abdomen
- 2 To determine the presence and kind of hepatic disease (atrophic cirrhosis, hypertrophic cirrhosis, syphilis of the liver, metastatic malignant lesions, primary tumor, abscess, cyst, and amyloidosis)
- 3 To ascertain whether metastatic le-



Fig 3



Fig 4

Fig 3 Hepar lobatum The liver is enlarged and lobulated Splenomegaly The patient is in fair general health nearly four years later (Case 3)

Fig 4 Extensive carcinomatous metastases in the liver Both lobes are greatly enlarged

sions are present in the liver if operation is contemplated for carcinoma

- 4 To demonstrate rupture of the liver or spleen
- 5 To determine the cause of jaundice (whether intrahepatic or due to obstruction of the common bile duct)
- 6 To follow the progress of hepatic or splenic disease
- 7 To demonstrate whether a lesion is above or below the diaphragm
- 8 To diagnose ascites
- 9 To study diseases of the spleen

Inasmuch as our experience has been much greater since the publication of this paper, we shall discuss each of these points in the light of such extended experience

1 It occasionally happens that clinicians are not able to determine whether a mass in the upper half of the abdomen is the liver or spleen or something else. From time to time we have employed hepatosplenography in order to settle this point. In most cases it has been possible definitely to state whether the liver or spleen is involved. In only one case were we definitely wrong in this connection. The liver was thought to be considerably enlarged, but operation showed that the

mass felt was an old appendiceal abscess which had pulled the liver downward and tilted it so that the shadow actually was larger than normal

2 Perhaps the greatest use of hepatosplenography is for the purpose of determining diseases of the liver

*Atrophic Cirrhosis*—We believe that cirrhosis of the liver may be detected by this procedure before other methods of diagnosis reveal it. In some cases the liver shadow is smaller than normal and diffusely mottled, with small areas of opacity in a background of greatly lessened density (Fig 2). The left lobe of the liver, however, may appear to be definitely enlarged, particularly when compared with the right. The spleen is practically always moderately enlarged. In other cases the liver may appear to be normal in size but either very finely mottled or casting a homogeneous shadow of definitely reduced density. These two appearances are dependent upon the architecture of the fibrous replacement of hepatic tissue, fibrous tissue not containing reticulo-endothelial cells

*Hypertrophic Cirrhosis*—When regeneration is rapid the liver may become quite

large, and in such an event the reticulo-endothelial cells containing the thorium dioxide are diffused in a large mass of parenchyma. Consequently, the enlarged organ casts a homogeneous shadow of lessened density, sometimes with a suggestion of mottling. The enlargement seems to involve mainly the right lobe of the liver, but this is more apparent than real. The spleen also is moderately enlarged.

*Syphilis of the Liver*—Lobulation of the liver due to the healing of gummatous hepatitis (hepar lobatum) gives a characteristic appearance (Fig 3). There is gross deformity and lobulation, frequently associated with mottling of relatively large areas. Syphilitic cirrhosis of the Lannec type, however, cannot be distinguished from atrophic cirrhosis due to other causes. The spleen may appear to be quite large.

*Metastatic Malignant Lesions*—When present in moderate number and of more than microscopic size, these lesions usually are readily observed in the hepatosplenograms. In cases in which the lesions are few and small, the liver may not be enlarged, but when there is extensive involvement the liver may become tremendously enlarged, both right and left lobes (Fig 4). There are multiple rounded areas of varying sizes and of greatly reduced density, representing malignant tissue, which usually does not contain reticulo-endothelial cells. These areas are usually surrounded by a halo of increased density (Fig 5). The spleen is usually not enlarged.

*Primary Tumor*—Diffuse primary carcinoma of the liver is difficult to differentiate by roentgen appearance alone from extensive metastatic involvement. The more rare single primary tumors are suggested by a large area of reduced density, with a somewhat irregular but usually fairly sharp outline in an enlarged organ. The halo of increased density is usually lacking. The spleen is not enlarged.

*Abscess*—Our experience with hepatosplenography in this condition is limited to one case. Both solitary and multiple ab-



Fig 5 Roentgenogram of a child, three years old (Case 5). Large carcinomatous metastasis may be seen in the left lobe of the liver, also, smaller nodule with a halo.

scesses should easily be noted, and when taken in conjunction with the clinical picture the diagnosis of the roentgenogram should be easy. The edge of the defect is "fuzzy."

*Cyst*—The same comment may be made in regard to cyst as to abscess except that the edge of the defect is sharper.

*Amyloidosis*—The roentgen appearance of amyloidosis is almost identical with that of hypertrophic cirrhosis of the liver, but there is not the slightest suggestion of mottling.

*Other Diseases of the Liver*—Such conditions as acute catarrhal jaundice, toxic or infectious hepatitis, and passive congestion of the liver produce nothing definitive in the hepatosplenogram. Focal necrosis may be suggested by the presence of small vacuoles.

3 We consider the use of thorium dioxide for determining whether or not meta-



stases are present in the liver as one of the very most important indications for the method. The diagnosis of this point has been wrong in exceedingly few cases. We are continuing to use this method almost as a routine for this purpose.

4 While rupture of the liver or spleen is determinable by hepatosplenography, our experience has been small and limited to two cases. For determining this point only 25 c c of the solution need be injected, and films may be taken as soon as two or even one hour thereafter. However, 50 c c would cast better shadows.

5 Further experience has shown that it is very rare to be able to determine the cause of severe jaundice not due to cirrhosis or associated with metastases. In chronic cases it may be possible to demonstrate the dilatation of the intrahepatic bile ducts.

6 Our original belief in regard to the value of hepatosplenography in determining the progress of hepatic disease by means of films taken at intervals of months or years has been greatly altered by the fact that changes in the architecture of the shadow occur as the result of partial elimination of the metal after the lapse of a few years. These changes will be described later. However, progression may at times be determined, as in cases of cirrhosis. It is probable also that metastases developing in a liver previously normal might readily be detected. We have had no experience in this connection.

7 In an occasional case it may be possible to obtain some help in determining the position of the diaphragm. This is probably not a very important field for hepatosplenography.

8 Ascites is easily detected by the method, in that the liver and spleen are separated from the lateral walls of the diaphragm.

9 We have come to the conclusion that hepatosplenography is of very little value in the diagnosis of diseases of the spleen.

#### CONTRA-INDICATIONS TO HEPATOSPENOGRAPHY

Our experience has shown that there are

no contra-indications yet established for the procedure. We have used the solution in cases of almost every kind without observing any definite deleterious effect. A number of our patients had severe jaundice of various durations and causes. Even in cases of acute hepatitis damage to the liver apparently has not resulted. We doubt also the suggested contra-indication of pulmonary tuberculosis, since the animal experimentation upon which this assumption was based has been found to be faulty.

In general, although we consider hepatosplenography harmless, it should not be used unless more simple methods of diagnosis fail. Some of the cases originally selected would not to-day be used, but in the beginning information was essential.

#### STUDY OF THE FIRST 200 CASES

A careful follow-up study has been made of the first 200 patients for whom thorium dioxide was employed. Of these, 47 are known to be living, and 36 have actually been re-examined both roentgenographically and generally. Bromsulphthalein tests of liver function and other studies as indicated have also been performed in a considerable number of cases. Of the living patients, confirmation of the clinical and roentgenological diagnoses was obtained in 10 instances either by biopsy of the liver or by celiotomy. Reports of those not actually examined have been received from the patients by social service workers or from the physicians involved. One hundred thirty-four patients are known to be dead, and the actual or approximate time of death is known in all. Definite diagnoses were obtainable in 73 (56 by necropsy, 15 by biopsy, and 23 by celiotomy). Nineteen patients could not be located, but a number of these are assumed to be living on the basis of their known pre-existing conditions (Table I).

Although the diagnoses in the vast majority of both living and dead patients in whom confirmation was not obtained were undoubtedly correct on the basis of clinical studies and roentgenograms, we shall discuss from the standpoint of accuracy of diag-

TABLE I—GENERAL SURVEY OF 200 CASES WITH HEPATOSPLENOGRAPHY

Status of Patients	Necropsy	Biopsy	Celiotomy
Living	47	3	9
Dead	134	12	9
Untraced	19	0	5
Total	200	15	23

TABLE II—DIAGNOSTIC ACCURACY OF HEPATOSPLENOGRAPHY IN 73 PROVED CASES

Correct	67	
Incorrect	6	
	Metastatic lesions in liver unsuspected	4
	Cirrhosis of liver not diagnosed	1
	Primary carcinoma diagnosed metastatic carcinoma	1
		6

nosis by hepatosplenography only those cases in which confirmation was obtained

The interpretation of the hepatosplenograms was proved to be correct in 67 of the 73 cases. Among the six cases wrongly diagnosed on this basis, there were four in which metastases were not apparent in the films but in which some very small ones were found to be present at necropsy. In another case cirrhosis of the liver was found to exist which had not been previously diagnosed. In still another, primary carcinoma of the liver was found but metastatic carcinoma had been diagnosed (Table II).

The value of hepatosplenography in the whole group of 200 patients is indicated by the following figures

- 1 The clinical diagnosis was confirmed in 61 cases
- 2 The diagnosis was made from the hepatosplenograms in 49 cases
- 3 The procedure was used to eliminate or to establish the presence of metastases in the liver in 46 cases
- 4 The method was of no help in making the diagnosis, or was of negative value in 35 cases
- 5 The diagnoses made on the basis of the films were wrong in six cases

Therefore, hepatosplenography was of definite value in the study of 156 of the 200 cases

The majority of the 200 patients were

suffering from some fatal malady. In 52 instances, the diagnosis of cirrhosis of the liver of one type or another was made either clinically or by more definite methods. Carcinoma of some organ was present in 58 cases, with metastases occurring in the liver in 38 cases. Leukemia of some type existed in 10 cases. Instances of other serious diseases occurred in smaller numbers.

#### REVIEW OF LIVING PATIENTS

The 47 patients who have received thorium dioxide and are still living were in the following age groups at the time of administration: First decade, 5, second decade, 1, third decade, 5, fourth decade, 14, fifth decade, 10, sixth decade, 6, seventh decade, 4, eighth decade, 2. The youngest patient was three years old, and the oldest 74 years old. There were 25 females and 22 males.

Some of the 26 different diagnoses made in this group of 47 patients were as follows: Lannec's cirrhosis (10 cases), syphilis of the liver (4 cases), hypertrophic cirrhosis of the liver (3 cases), chronic lymphatic leukemia (2 cases), myeloid leukemia (1 case), acute catarrhal jaundice (1 case), sickle-cell anemia (3 cases), splenic anemia (1 case), obstruction of the common bile duct (1 case), purpura hemorrhagica (1 case), left lobectomy for liver abscess (1 case), sarcoma of the leg with metastases to the liver (1 case). The other diagnoses were of various diseases of one case each, in which the liver and spleen were eliminated as part of the morbid anatomy.

The lengths of time elapsing between the administration of thorium dioxide and March 15, 1936, were as follows: Less than one year, seven, between one and two years, seven, between two and three years, eight, between three and four years, 11, between four and five years, 14. The first patient injected is still living and well, in spite of chronic lymphatic leukemia four years and nine months after the injection of 60 c c of thorium dioxide sol.



Fig 6

Fig 6 There is seen an absence of the left lobe of the liver due to lobectomy for solitary abscess. The spleen is small, irregular, and dense.



Fig 7

Fig 7 Hepatosplenogram taken nearly four years after the injection of thorium dioxide. Syphilitic cirrhosis (Case 8). Lobulation of liver. The fine linear mottling is due to contrast medium in the lymphatics of the liver. The opaque masses between the liver and spine are lymph nodes containing mobilized thorium dioxide.

#### RE-EXAMINATION OF LIVING PATIENTS

Of the 47 patients known to be living, 36 have been re-examined either at intervals or within very recent date of the writing of this report, both from the general clinical standpoint and by x-ray films of the abdomen. The bromsulphthalein test of liver function, selected as being the most generally useful test of liver function, was performed in 25 of these patients. Of these 25 patients, 12 had had acute disease of the liver or were suffering from chronic disease of that organ. Six were definite cases of cirrhosis, three were cases of syphilis of the liver, one was an unusual case of a man whose left lobe of the liver had been removed for solitary liver abscess (Fig 6), one was a patient who had had acute hepatitis, and one was a patient who had been operated upon for obstruction of the common bile duct. This group of 12 cases is particularly significant in illustrating the harmlessness of stabilized thorium dioxide sol, both as to the effect of the prolonged presence of myriads of foreign bodies in the reticulo-endothelial system generally and in the liver particularly, and as to the question of radio-activity of the metal in the

dosage employed. Two of the patients had been injected with thorium dioxide between one and two years previously, three between two and three years, two between three and four years, and four between four and five years. All but four of these patients are in excellent health subjectively, three are fairly well, and only one has progressed to a serious state of hepatic insufficiency clinically. Only four of the patients show retention of bromsulphthalein in the blood at the end of 30 minutes. Of the 13 other patients who did not have disease of the liver and on whom the bromsulphthalein test was performed, only one showed retention of the dye at the end of 30 minutes, and that was a patient with congestive heart failure and chronic passive congestion of the liver. The amount of dye recovered at the end of five minutes in these cases ranged from 30 to 70 per cent.

In the whole group of patients re-examined, particular attention was given to the question of intercurrent infection, for example, grippe, common respiratory infections, etc., and it was surprising to note the relative infrequency of these diseases in the

group Only one patient had any serious intercurrent infectious disease (mastoiditis with operation and recovery) Of the children, three are in perfect health several years after the injection of thorium dioxide The other two are in fairly good health, but one has xanthomatosis and the other has sickle-cell anemia

#### REVIEW OF THE PATIENTS WHO HAVE DIED

All of the 134 patients who are dead were suffering from advanced, serious, usually chronic, but in three instances acute disease Thirty-four were cases of advanced cirrhosis of the liver, 61 of carcinoma, seven of leukemia, five of malignant lymphoma, two of amyloidosis, two of tuberculous peritonitis, two of disseminated tuberculosis, two of congestive heart failure, two of pneumonia, and there was one case each of Felty's syndrome, septicemia following amputation of the leg, subphrenic abscess, uremia, empyema of the gall bladder, brain abscess, sickle-cell anemia, malignant melanoma, Paget's disease, rupture of the spleen, and coronary thrombosis In six cases the diagnosis was undetermined Most of the patients died within a year, but some lived longer and one lived even three years and six months (cirrhosis of the liver) Eleven of the patients now dead were rechecked roentgenographically after the injection of thorium dioxide, four within one year, five between one and two years, one between two and three years, and one between three and four years

#### ROENTGENOGRAPHIC APPEARANCES ON RE-EXAMINATION

In 47 of the 200 cases, roentgenologic re-examinations were made, in most instances only once, but in several instances several times at intervals of months or years In 20 cases there was relatively little change in the appearance of the roentgenogram In a few of these there was definite diminution in the density of the hepatic and splenic shadows Usually both organs were affected similarly, but occasionally one or the other was affected to a greater degree

TABLE III —ROENTGENOGRAPHIC APPEARANCES ON RE-EXAMINATION OF 47 CASES

No change or slight diminution in density of liver and spleen	20
Evidence of cirrhosis not present on first examination	2
Cases showing mottling of liver or (and) spleen	22
Cases showing visible lymph nodes near liver or (and) spleen	14
Cases showing both mottling of liver or (and) spleen and visible lymph nodes	10

Of the 20 cases, seven had been re-examined within one year, seven between one and two years, one between two and three years, and five between three and four years after the administration of the thorium dioxide In two cases changes were noted in the liver which were additional aids in the diagnosis In both, the liver had appeared normal on the first examination, whereas in the progress films definite evidence of cirrhosis was apparent Both had been merely suspected of having cirrhosis at the time of the first examination (Table III)

In 26 cases definite evidence was shown on the films of mobilization or elimination of the thorium dioxide This took the form either of mottling of the liver or spleen or both, or of the existence of visible lymph nodes either between the liver and the spine, or between the spleen and the spine However, in only 10 were there both mottling of one or both of these organs and visible lymph nodes together The mottling of the liver or spleen or both organs was present in 22 rechecked cases The visible lymph nodes were present in 14 rechecked cases

The shortest period of time after the administration of thorium dioxide that mottling was noted was one year and one month, the longest period was four years and 11 months There was very little difference in the periods of time elapsing, however, between the cases with mottling and those without For instance, there were seven cases without mottling in which the metal had been injected over three years before the re-examination In the case of the patient with the longest time, namely, four years and nine months, there

was no mottling. In the cases in which there was mottling, both the liver and spleen were affected in nine, the liver alone

served in any of our cases of cirrhosis at the time of the original examination.

The mottling of the spleen also took two



Fig 8 Hepatosplenogram, taken nearly four years after the injection of thorium dioxide. The liver and spleen are normal. The spleen is diffusely mottled. Visible lymph nodes may be seen between the liver and spine.

in nine, and the spleen alone in five. In all cases in which both the liver and spleen were mottled, the thorium dioxide had been injected more than three years before.

The mottling of the liver was of two types. In one, which occurred more often, there was a very fine, punctate, uniform mottling which was close-set and dimly apparent. In the other, the mottling took the form of small, distinct, linear and somewhat interlacing shadows not so closely set (Fig 7). This latter type gave definitely the appearance of some opaque substance in the lymphatics of the organ. It also gave the definite impression of considerable reduction of the amount of the metal in the liver. Neither type of mottling would often be confused with that due to cirrhosis, since in the first type the mottling is much more compact and relatively indistinct, whereas the form of mottling seen in the second type had not been ob-

forms. One form was very similar to that of the first form described for the liver, the other consisted of a larger type of rounded mottled areas from 1 to 1.5 mm in diameter, distinctly separated one from the other and giving the organ the appearance of a honeycomb (Fig 8). This type of mottling is occasionally seen in the spleen on the original examination after the injection of thorium dioxide.

The lymph nodes were visible on both sides of the spine near the liver and spleen in only three of the 14 cases in which the lymph nodes were visible. In 10 cases the lymph nodes were visible only between the liver and the spine, and in only one case were the lymph nodes visible between the spleen and the spine alone. These lymph nodes were usually quite distinct and quite dense, and were undoubtedly due to the presence of relatively large amounts of thorium dioxide in the nodes draining the

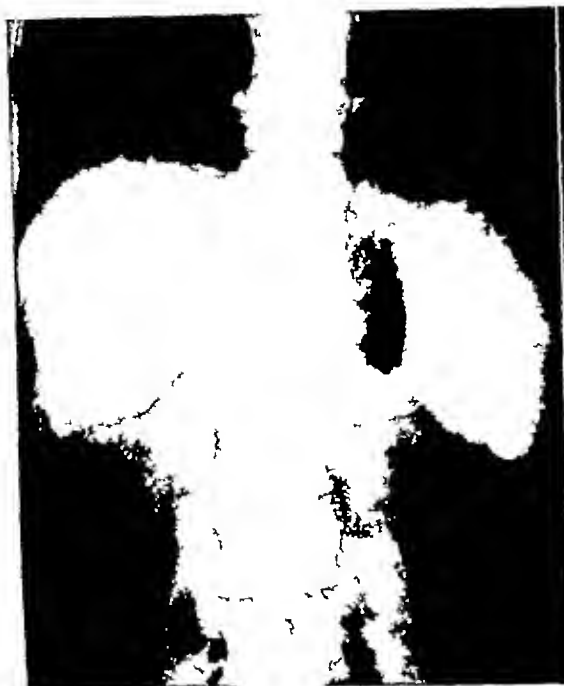


Fig 9



Fig 10

Fig 9 Hepatosplenogram taken more than four years after the injection of thorium dioxide. Atrophic cirrhosis (Case 1). The right lobe of the liver decreased in size whereas the left lobe enlarged. The spleen is slightly enlarged. The liver shows fine linear mottling due to contrast medium in the lymphatics of the liver. The spleen is finely mottled. The lymph nodes containing thorium dioxide, are visible on the right side of the spine. Figure 10 is made from the original hepatosplenogram. The patient is in good general health.

Fig 10 Case 1. The liver is small but its structure is not altered. The left lobe is somewhat enlarged. The spleen is normal. Figure 9 is a hepatosplenogram made more than four years later.

liver or the spleen, or both (Fig 9). In four additional cases there was some question as to the visibility of the lymph nodes, as they were not definitely visible in any case in which the metal had been injected less than a year before. There was only one case in which it had been injected less than two years before. In the case which has gone four years nine months, the lymph nodes were visible only in the region of the porta hepatis. However, in many of the cases in which the lymph nodes were not visible considerable time had elapsed following the injection of the thorium dioxide. In fact, there were five cases in which the injection had been made four years or more previously. We feel justified in assuming, therefore, that the mobilization and, therefore, the elimination of thorium dioxide from the reticulo-endothelial cells of the liver and spleen is, on the whole, a slow process, and its rapidity varies consider-

ably in individual cases. Just how long it would take in the majority of cases for all of the metal to be eliminated from the body or even from the liver and spleen is impossible to conjecture with any degree of accuracy.

It has already been stated that the resistance to infection in patients who have received thorium dioxide in the doses employed did not appear to be diminished. Nor was there any evidence clinically that there had been damage to the liver which could be attributed to the metal. In addition, there has been no evidence of radium poisoning in any of the patients up to the present time. Furthermore, in those few cases in which thorium dioxide had been injected erroneously, usually in small amounts, into the tissues surrounding the vein there has been no evidence of the development of sarcomas at that point.

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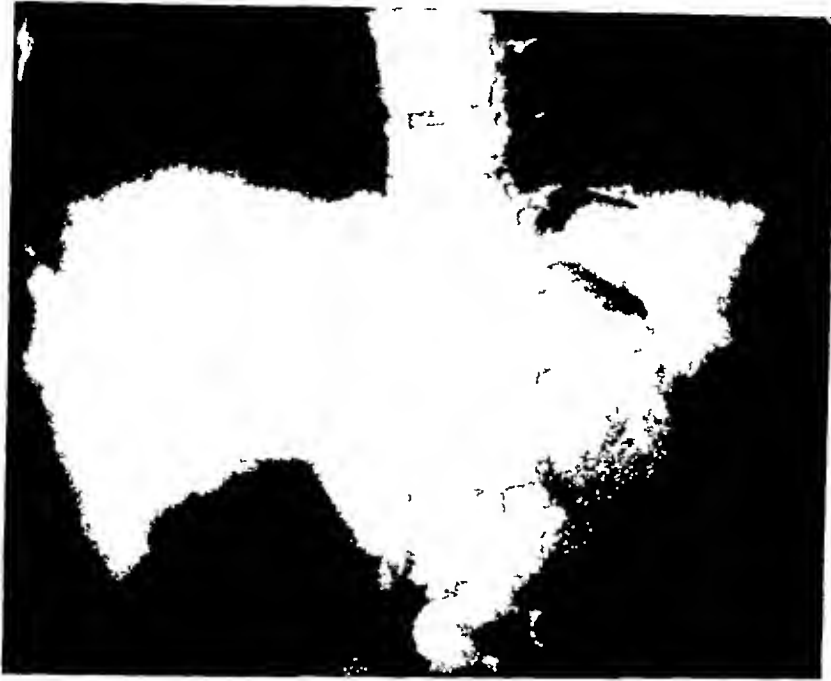


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visible in the right lobe, at the lower edge of which there was a smooth, sharp defect, which had the appearance of surgical intervention. The spleen appeared to be normal in size and density, and there was an accessory spleen. This patient has been re-examined at intervals and was last seen on March 23, 1936. Except for occasional attacks of "indigestion" and nervousness she has been quite well, and the physical examination has been essentially negative. A bromsulphthalein test on Nov 15, 1935, showed retention of 40 per cent after five minutes and none at the end of 30 minutes. A hepatosplenogram made Oct 22, 1932, over eight months after the first, showed the liver shadow somewhat less dense and very finely mottled. The right lobe was about the same size, but the left lobe was somewhat enlarged. The spleen was about the same size but slightly more dense. Another film made Jan 14, 1933, showed evidence of ascites. The liver was definitely mottled, and the spleen was somewhat enlarged. A film made on March 16, 1936, more than four years after the original film, showed definite diminution in the density of the liver and fine linear markings of metal in the lymphatics (Fig 9). The right lobe was small and the left lobe seemed to be as large as the right. In the region of the porta hepatis there were dense opacities undoubtedly representing lymph nodes containing thorium dioxide. The spleen was of the same size and very finely mottled. This patient undoubtedly has cirrhosis of the liver, but this was demonstrated before the injection of thorium dioxide, and four years of moderately good health without laboratory evidence of impairment of liver function have followed the injection of the metal.

Case 2<sup>6</sup> The patient, M. A., a white woman aged 28 years, was admitted to the Georgetown University Hospital on Sept 22, 1931, complaining of severe weakness of two weeks' duration, with nausea and occasional vomiting after meals, moderately

severe and fairly constant lower abdominal pain, and profuse vaginal discharge. The general physical examination was essentially negative except for some evidence of pelvic inflammatory disease and moderately severe anemia. Four days after admission she received 500 c c of citrated blood with no apparent reaction, but three days later it was noted that she was slightly jaundiced. Shortly thereafter, the van den Bergh reaction was reported as prompt direct with 5 mg of the bilirubin per 100 c c of blood, and ten days later the quantitative reaction showed 25 mg per 100 c c. After another 10 days it had risen to 35 mg per 100 c c. At this time, in view of the increasing intensity of the jaundice and a history of recurring attacks of severe upper abdominal pain which had occurred shortly before admission, it was decided to perform a laparotomy to determine whether cholelithiasis with obstruction of the common bile duct existed. Stones were not found. The liver was normal in size and shape but seemed unusually firm. The spleen was somewhat enlarged. There was a moderate amount of bile-stained fluid in the abdominal cavity. A section was removed from the liver edge for biopsy. The ascites, which had not been evident clinically, increased greatly during the first few post-operative days and drained freely through the incision. Evidence of ascites persisted for about two weeks and then gradually disappeared. The van den Bergh reaction showed a gradual decline following the laparotomy. The readings at approximately weekly intervals were 15 mg, 7.8 mg, and 2 mg per 100 c c of blood. The bromsulphthalein test of liver function done after the ascites had disappeared showed 75 per cent retention in five minutes and 15 per cent in 30 minutes. The stools showed bile throughout the course. Biopsy of the liver showed the following: "There is a slightly thickened capsule and considerable periportal fibrosis. Marked edema and round-cell infiltration obscure the normal hepatic picture, also, there is a pronounced regenerative

<sup>6</sup> Reported as a case of jaundice with ascites and recovery by J. R. Cavanagh, M.D., in *Med Ann of the District of Columbia* 1935 4, 322.



# PRELIMINARY REPORT OF HISTOPATHOLOGIC STUDIES OF 71 CASES<sup>5</sup>

The thorium dioxide in sections stained with hematoxylin and eosin appears as brownish-gray granules, especially in the liver and spleen. In the liver there are oval or round masses of these granules in the sinusoids, there is none in the liver cells and rarely very much in the connective tissue of the portal areas. The masses have the size and outline of the reticulo-endothelial cells, but usually the granules are so abundant that the nuclei of these cells cannot be seen, however, in some cases they are less numerous, and the nuclei are distinctly visible.

In many of the cases the masses of granules are distributed quite uniformly through the liver lobule, in some, however, the masses tend to form groups anywhere in the lobule but at times in the central zone. In cases of chronic passive congestion, with atrophy of liver cells and widening of the sinusoids in the central zone, this grouping in the central zone may be more apparent than real.

In none of the cases is there the slightest evidence of any injury to the liver cells, irrespective of the length of time the metal has been present. Even in the cases in which the masses of granules are grouped in the sinusoids, the liver cells lying next to and around these groups are normal in size, appearance, and staining properties, and do not contain fat or blood pigment. There is no cellular reaction or fibrosis in the liver in the region of these masses, indicating any effort to wall off the masses.

The same appearance exists in the splenic pulp, except that there the granules are frequently seen as blotches and patches, in addition to the oval or round compact masses. There is not nearly as great accumulation of the granules in the splenic corpuscles as in the pulp, and there is very little in the connective tissue of the trabeculae and capsule. At times, however, the masses of granules outline the fibrous

trabeculae and occasionally the blood vessels. There is no evidence of any cellular reaction or fibrosis in the spleen in the region of these masses.

Relatively small amounts of thorium dioxide are present in the other organs and the lymph nodes. Again, there is no evidence of any reaction that can be attributed to the presence of the metal.

## REPORTS OF CASES ILLUSTRATING THE HARMLESSNESS OF HEPATOSPLENOGRAPHY

Case 1. A white woman, I. D., aged 49 years, was admitted to the Georgetown University Hospital on Nov. 20, 1931, with jaundice of four weeks' duration and epigastric pain of two weeks' duration. The van den Bergh reaction before operation was 37.5 mg. per 100 c.c. of blood. Although considered by the medical consultants to be a case of hepatitis, the surgeon believed an exploratory operation advisable. This was performed on Dec. 5, 1931. Obstruction of the common bile duct was not found, but the liver did not appear normal. Cholecystotomy was performed. Report of biopsy of the liver was as follows: "There is complete disappearance of the liver lobules, only the ducts remaining in the specimen submitted. The latter are dilated and lined by regular epithelium. The liver parenchyma has been replaced by firm connective tissue, apparently of long standing. Evidently there has been superimposed upon this chronic fibrosing process an acute one characterized by large areas of leukocytic infiltration." The jaundice slowly subsided, the van den Bergh reaction reaching normal by Feb. 10, 1932. A bromsulphthalein test of liver function performed two weeks later showed 50 per cent retention after five minutes and none at the end of 30 minutes. On Feb. 4, 1932, after injection of 60 c.c. of stabilized solution of thorium dioxide, hepatosplenograms were made. These showed the liver to be quite small, the medium well concentrated, and no apparent alteration of structure (Fig. 10). The vessels were

<sup>5</sup> By Dr. Eugene R. Whitmore. Complete report will appear later.

visible in the right lobe, at the lower edge of which there was a smooth, sharp defect, which had the appearance of surgical intervention. The spleen appeared to be normal in size and density, and there was an accessory spleen. This patient has been re-examined at intervals and was last seen on March 23, 1936. Except for occasional attacks of "indigestion" and nervousness she has been quite well, and the physical examination has been essentially negative. A bromsulphthalein test on Nov 15, 1935, showed retention of 40 per cent after five minutes and none at the end of 30 minutes. A hepatosplenogram made Oct 22, 1932, over eight months after the first, showed the liver shadow somewhat less dense and very finely mottled. The right lobe was about the same size, but the left lobe was somewhat enlarged. The spleen was about the same size but slightly more dense. Another film made Jan 14, 1933, showed evidence of ascites. The liver was definitely mottled, and the spleen was somewhat enlarged. A film made on March 16, 1936, more than four years after the original film, showed definite diminution in the density of the liver and fine linear markings of metal in the lymphatics (Fig 9). The right lobe was small and the left lobe seemed to be as large as the right. In the region of the porta hepatis there were dense opacities undoubtedly representing lymph nodes containing thorium dioxide. The spleen was of the same size and very finely mottled. This patient undoubtedly has cirrhosis of the liver, but this was demonstrated before the injection of thorium dioxide, and four years of moderately good health without laboratory evidence of impairment of liver function have followed the injection of the metal.

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process The picture is that of a subacute inflammatory process" Hepatosplenograms made on Dec 10, 1931, after the injection of 60 c c of thorium dioxide solution, showed the liver "length" to be 25.5 cm and the "thickness" to be 13.5 cm, which is above the average in size There was a moderate degree of mottling which gave the appearance of early cirrhotic change The spleen was normal in size The temperature was normal throughout the course in the hospital, as were the pulse and respiration, except when the post-operative hemorrhage occurred Treatment consisted chiefly of transfusions and administration of large amounts of glucose solution intravenously and subcutaneously Since that time the patient has been under observation and has been fairly well except for attacks of severe abdominal distress simulating partial intestinal obstruction occurring at intervals of from three to four months and lasting about a week She is otherwise well, has been married twice, and is able to perform all of the duties of a nurse On Sept 11, 1935, roentgenographic films of the liver and spleen were again made, nearly four years after the first These showed no appreciable diminution in the intensity of the shadows The liver and spleen were approximately the same size as at the previous examination, except for a slight decrease in the volume of the spleen The liver showed some gross and also fine granular mottling The spleen had a peculiar honeycomb-like appearance There was an opaque meshwork beneath the lower part of the right lobe of the liver, which evidently represented the medium in the lymphatic vessels There were also deposits, probably of thorium dioxide, in the hepatic and splenic lymph nodes A bromsulphthalein test at this time showed 70 per cent retention after five minutes but none at the end of 30 minutes

Case 3 A white woman, D. M., aged 36 years, entered the Out-patient Department of Georgetown University Hospital on Oct 15, 1931, complaining of "indigestion" and pain in the hypochondriac re-

gions Twelve years previously, while suffering from the same symptoms, she had been found to have syphilis, for which she had been treated intermittently Physical examination showed slight jaundice, moderate enlargement of the thyroid gland, and considerable enlargement of the liver, which was firm and irregular The spleen was also moderately enlarged The Wassermann and Kahn tests of the blood were four plus There was moderate anemia Antisyphilitic treatment was begun with bismuth and mercury On Feb 15, 1932, the bromsulphthalein test of liver function showed 45 per cent retention at the end of five minutes and none after 30 minutes The van den Bergh reaction was indirect, with 1.25 unit Hepatosplenograms made on March 22, 1932, after the injection of 75 c c of stabilized thorium dioxide sol, showed considerable enlargement of both liver and spleen (Fig 3) The former had large lobulations, the latter was homogeneous The appearance was definitely that of *hepar lobatum* After several months the patient failed to return for treatment She was not seen again until Jan 18, 1936 In November, of 1934, she had had attacks of pain in the upper sternal region associated with dyspnea Antisyphilitic treatment was given in a physician's office In January, of 1935, she became pregnant and developed edema of the extremities and hypertension which went as high as 225 systolic In October, of 1935, she gave birth to an apparently normal infant, whom she was still nursing The edema had not entirely disappeared The attacks of upper sternal pain and dyspnea continued to recur at intervals, but she said she felt well and was working Physical examination showed the liver to be somewhat larger than before, and firm and nodular The spleen was about the same size as in October, 1931 Hepatosplenograms made on Jan 18, 1936, nearly four years after the first, showed some reduction in density of the liver shadow, and an irregular, fine mottling The lobulations were not as distinct as before The spleen was of ap-



Fig 11

Fig 11 Case 4 Original hepatosplenogram The spleen is moderately enlarged



Fig 12

Chronic lymphatic leukemia The liver is normal

Fig 12 Case 4 Hepatosplenogram made nearly five years after the injection of thorium dioxide There is a moderate reduction in density of the liver and spleen Same appearance otherwise as in the original film A small lymph node is visible at the porta hepatis The patient is in good health

proximately the same size and density as originally There were visible lymph nodes between the spleen and the spine The patient would not remain for laboratory tests

Case 4 The patient, M C, a white woman, aged 58 years, was first seen in October, 1930 She was complaining of abdominal "gas," with eructations and some gastric distress Several months previously she had been found to have chronic lymphatic leukemia, and x-ray therapy had restored the hemogram to normal The physical examination was negative except for moderate splenomegaly The symptoms responded to symptomatic treatment On July 11, 1931, hepatosplenograms after the injection of 60 cc of stabilized thorium dioxide sol showed an apparently normal liver, the spleen was moderately enlarged (Fig 11) The kidneys were well visualized, an occasional occurrence when thorium dioxide is used The patient continued teaching school, in good health In April, 1935, however, the hemogram again showed evidence of lymphatic leukemia, and x-ray therapy was repeated Hepatospleno-

grams, made on April 25, 1935, showed the liver shadow to be somewhat less dense than originally The spleen was somewhat larger and less dense than the liver A small lymph node at the porta hepatis was visible In August, 1935, the patient was well and the hemogram normal The same was true in November, 1935, and again on April 10, 1936 On the latter date, just four years and nine months after the injection of thorium dioxide, hepatosplenograms showed the same condition existing as on April 25, 1935 (Fig 12) The liver and spleen were well demonstrated and of only moderately reduced density compared with the original films Some of the contrast medium had been accidentally injected into the tissues of both arms These areas were hardened tumefactions, but there was no evidence of sarcomatous or other change The hemogram was essentially normal

#### REPORT OF CASE ILLUSTRATING THE VALUE OF HEPATOSPLENOGRAPHY TO DETERMINE PRESENCE OF METASTASES

Case 5 The patient, G T, a negro girl aged three years, developed a large

process The picture is that of a subacute inflammatory process" Hepatosplenograms made on Dec 10, 1931, after the injection of 60 c c of thorium dioxide solution, showed the liver "length" to be 25.5 cm and the "thickness" to be 13.5 cm, which is above the average in size There was a moderate degree of mottling which gave the appearance of early cirrhotic change The spleen was normal in size The temperature was normal throughout the course in the hospital, as were the pulse and respiration, except when the post-operative hemorrhage occurred Treatment consisted chiefly of transfusions and administration of large amounts of glucose solution intravenously and subcutaneously Since that time the patient has been under observation and has been fairly well except for attacks of severe abdominal distress simulating partial intestinal obstruction occurring at intervals of from three to four months and lasting about a week She is otherwise well, has been married twice, and is able to perform all of the duties of a nurse On Sept 11, 1935, roentgenographic films of the liver and spleen were again made, nearly four years after the first These showed no appreciable diminution in the intensity of the shadows The liver and spleen were approximately the same size as at the previous examination, except for a slight decrease in the volume of the spleen The liver showed some gross and also fine granular mottling The spleen had a peculiar honeycomb-like appearance There was an opaque mesh-work beneath the lower part of the right lobe of the liver, which evidently represented the medium in the lymphatic vessels There were also deposits, probably of thorium dioxide, in the hepatic and splenic lymph nodes A bromsulphthalein test at this time showed 70 per cent retention after five minutes but none at the end of 30 minutes

Case 3 A white woman, D M, aged 36 years, entered the Out-patient Department of Georgetown University Hospital on Oct 15, 1931, complaining of "indigestion" and pain in the hypochondriac re-

gions Twelve years previously, while suffering from the same symptoms, she had been found to have syphilis, for which she had been treated intermittently Physical examination showed slight jaundice, moderate enlargement of the thyroid gland, and considerable enlargement of the liver, which was firm and irregular The spleen was also moderately enlarged The Wassermann and Kahn tests of the blood were four plus There was moderate anemia Antisyphilitic treatment was begun with bismuth and mercury On Feb 15, 1932, the bromsulphthalein test of liver function showed 45 per cent retention at the end of five minutes and none after 30 minutes The van den Bergh reaction was indirect, with 1.25 unit Hepatosplenograms made on March 22, 1932, after the injection of 75 c c of stabilized thorium dioxide sol, showed considerable enlargement of both liver and spleen (Fig 3) The former had large lobulations, the latter was homogeneous The appearance was definitely that of *hepar lobatum* After several months the patient failed to return for treatment She was not seen again until Jan 18, 1936 In November, of 1934, she had had attacks of pain in the upper sternal region associated with dyspnea Antisyphilitic treatment was given in a physician's office In January, of 1935, she became pregnant and developed edema of the extremities and hypertension which went as high as 225 systolic In October, of 1935, she gave birth to an apparently normal infant, whom she was still nursing The edema had not entirely disappeared The attacks of upper sternal pain and dyspnea continued to recur at intervals, but she said she felt well and was working Physical examination showed the liver to be somewhat larger than before, and firm and nodular The spleen was about the same size as in October, 1931 Hepatosplenograms made on Jan 18, 1936, nearly four years after the first, showed some reduction in density of the liver shadow, and an irregular, fine mottling The lobulations were not as distinct as before The spleen was of ap-



Fig 11

Fig 11 Case 4 Original hepatosplenogram The spleen is moderately enlarged



Fig 12

Fig 12 Case 4 Hepatosplenogram, made nearly five years after the injection of thorium dioxide There is a moderate reduction in density of the liver and spleen Same appearance otherwise as in the original film A small lymph node is visible at the porta hepatis The patient is in good health

proximately the same size and density as originally There were visible lymph nodes between the spleen and the spine The patient would not remain for laboratory tests

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#### REPORT OF CASE ILLUSTRATING THE VALUE OF HEPATOSPLENOGRAPHY TO DETERMINE PRESENCE OF METASTASES

Case 5 The patient, G T, a negro girl aged three years, developed a large

mass in the left side of the abdomen. This was determined to be a neoplasm of the left kidney, which was removed and found to be a Wilms' tumor. Seven weeks later, 12 c c of stabilized thorium dioxide sol was injected intravenously and a hepatosplenogram made (Fig 5). This showed the liver to be greatly enlarged downward and to the left. In the right lobe there was a large, more or less homogeneous, rounded area of lessened density. Within this area there was another round area of diminished opacity surrounded by a halo. Only a small portion of liver tissue remained below this. The left lobe of the liver was somewhat enlarged. The spleen appeared normal. Celiotomy a week later revealed ascites and confirmed the presence of large metastatic lesions in the liver. The child died three weeks later.

#### REPORT OF CASE ILLUSTRATING THE DIAGNOSTIC VALUE OF HEPATOSPLENOGRAPHY

Case 6. A negress, H. M., aged 52 years, entered Gallinger Municipal Hospital on June 25, 1933, complaining of nausea and vomiting of four months' duration. There had also been more or less constant epigastric pain and two attacks of probable hematemesis. Loss of weight and strength was also noted. Chronic alcoholism was admitted. The patient was emaciated, and there were many râles over both lung-fields. Tenderness was elicited in the epigastrium, but masses were not palpable. There was definite anemia, and the Kahn test of the blood was four plus. A roentgenogram of the chest showed evidence of tuberculosis, but the sputum was negative. A gastrointestinal x-ray study was thought to reveal evidence of a lesion of the stomach. Hepatosplenograms made on July 3, 1933, after the injection of 75 c c of stabilized thorium dioxide sol, showed the left lobe of the liver to be enlarged and the whole organ to be diffusely mottled, as in cirrhosis. The spleen was not definitely enlarged. Celiotomy, on July 26, did not reveal a lesion of the stomach but showed the liver

to be enlarged, lobulated, mottled, and scarred. The patient was re-admitted to the Hospital in October, 1935. She had improved greatly, but recently frequent attacks of epigastric pain and vomiting had recurred. The physical examination was the same. There was 5 per cent retention of bromsulphthalein at the end of 30 minutes. Hepatosplenograms made on Oct. 15, 1935, more than two years after the first, showed essentially the same condition as originally, but the granulation of the liver was much more definite (Fig 2). The patient was discharged three weeks later, greatly improved.

#### REPORTS OF CASES ILLUSTRATING THE DIAGNOSTIC VALUE OF "PROGRESS FILMS"

Case 7. A white man, P. S., aged 45 years, had had pleurisy with effusion in the latter part of 1931. While still ill in April, 1932, he developed gangrenous appendicitis. After recovery from this he continued to have a little fever daily, some dyspnea, cough, and abdominal distention. In September, 1932, there was definite ascites and hepatomegaly. With treatment, these abnormalities slowly disappeared in the next six months but the patient continued to feel weak. In December, 1933, the bromsulphthalein test of liver function showed 80 per cent retention in five minutes and 20 per cent after 30 minutes. Hepatosplenograms, made on Feb. 6, 1934, after the injection of 75 c c of contrast medium, were apparently normal. The patient continued to feel weak but had no definite symptoms. Hepatosplenograms, made on Sept. 9, 1935, a year and a half after the first, now showed a definite granular appearance of the liver, and the left lobe was seen to be considerably enlarged. There was no ascites. The diagnosis of cirrhosis of the liver was established. The liver function test showed 100 per cent retention of bromsulphthalein in five minutes and 20 per cent after 30 minutes.

Case 8. A negro, J. G., aged 55 years, was admitted to the Gallinger Municipal Hospital on June 1, 1932, complaining of



abdominal distention and weakness of several months' duration, with marked loss of weight. He had not used alcoholic beverages. Physical examination showed slight jaundice, some ascites, and moderate enlargement of the liver. The Kahn test of the blood was four plus. The van den Bergh reaction was mainly indirect, with 2.5 units. A hepatosplenogram, made on June 16, 1932, after the injection of 75 c.c. of contrast medium, showed the liver and spleen to be normal in size, contour, and position without evidence of organic change. Other diagnostic studies were negative. Syphilitic disease of the liver was suspected. The abdomen was tapped, with withdrawal of ascitic fluid, and anti-syphilitic treatment was instituted. He got along fairly well except for mastoiditis in July, 1935. The size of the abdomen fluctuated from time to time. He was re-examined on Nov. 11, 1935, and again on March 30, 1936, in the Out-patient Department. There was no evidence of ascites. The liver was definitely enlarged, but the spleen could not be felt. Hepatosplenograms on both occasions, the last nearly four years after the original films, showed the liver somewhat smaller than before, with enlargement of the left lobe and definite lobulation very suggestive of *hepar lobatum* (Fig. 7). The liver was considerably less dense than before, and showed evidence of the thorium dioxide having migrated to the lymph channels. The spleen was slightly larger but of the original density. There was a questionable visible lymph node near the spleen. A bromsulphthalein test showed 100 per cent retention after five minutes and 30 per cent after 30 minutes. The diagnosis of *hepar lobatum* was now definitely established. The patient was living and in fair general health four years after ascites was known to have been present.

#### EXPERIENCE OF OTHER INVESTIGATORS

There are two schools of thought regarding the danger of hepatosplenography by means of thorium dioxide. Several investigators, including Anders and Leitner

(10), Buchner (11), Shute and Davis (12), Cooke (13), Hanke (14), and Pohle and Ritchie (15), are rather opposed to its use, but, in our opinion, without sufficient evidence. Objections have generally been based upon animal experiments extending over periods of days, weeks, and months. Often the dosage employed was comparatively many times that necessary for hepatosplenography in man. The acute changes produced, such as necrosis, cloudy swelling, and atrophy in the liver, spleen, and lymph nodes, have caused the greatest comment, but with moderate dosage permanent damage to these organs has not resulted. Other workers, such as Radt (3 and 4), Irwin (16), Dickson (17), Kadrnka (18), Whitaker, Davis, and Murgatroyd (19), Tripoli, Haam, and Lehmann (20), Ravenna (21), Ericksen and Rigler (22), Tripoli (23), Hirsh and Morton (24), Robins and Goldberg (25), and Rigler, Koucky, and Abraham (26), believe it is a relatively harmless procedure. Naturally, most of these have urged caution until all danger of latent radio-activity has been excluded. Unfortunately Radt (27), whose experience is the longest, has left Berlin and has lost his records and access to his patients. He still believes the method to be without danger.

The experience of Rigler, Koucky, and Abraham (26) is very similar to ours. In November, 1935, they reported on the use of thorium dioxide in 175 patients studied over a period of three and one-half years. Their clinical material included mainly patients with malignant neoplasms, and all but 43 had died at the time of their report. Some had lived a number of years, but only two had lived more than three and one-half years. In the entire series there were only two serious reactions, and one was probably not due to the thorium dioxide. Liver function tests showed no evidence of impairment, and there was no evidence of increased susceptibility to infection. Histopathologic studies in 35 cases revealed few, if any, changes attributable to the presence of the metal or similar to those observed in animals examined soon after



mass in the left side of the abdomen. This was determined to be a neoplasm of the left kidney, which was removed and found to be a Wilms' tumor. Seven weeks later, 12 c c of stabilized thorium dioxide sol was injected intravenously and a hepatosplenogram made (Fig 5). This showed the liver to be greatly enlarged downward and to the left. In the right lobe there was a large, more or less homogeneous, rounded area of lessened density. Within this area there was another round area of diminished opacity surrounded by a halo. Only a small portion of liver tissue remained below this. The left lobe of the liver was somewhat enlarged. The spleen appeared normal. Celiotomy a week later revealed ascites and confirmed the presence of large metastatic lesions in the liver. The child died three weeks later.

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the injection of very large doses. Repeated roentgenographic examinations in 22 cases from one to three and one-half years after the injection indicated little or no elimination, but redistribution of the metal into the lymphatics of the liver with extension into the hepatic lymph nodes was observed in almost all cases re-examined after a year or more had elapsed.

So far as we know no fatal reactions have resulted from the clinical use of the proper solution of thorium dioxide. The spontaneous rupture of the spleen reported by Bungeler and Krautwig (28) may have been due to its use, but we do not believe there is much proof for this assumption.

Various changes in the blood picture and in the bone marrow have been observed by some investigators working with animals, but clinicians have not observed more than transient and minor changes in the hemograms of patients.

#### SUMMARY AND CONCLUSIONS

A review has been made of 200 cases in which hepatosplenography with stabilized thorium dioxide sol was employed as a diagnostic aid during the past five years. The procedure was of value in 156 cases. The diagnosis was made almost entirely on the basis of the hepatosplenograms in 49 cases.

The use of thorium dioxide in the form and amounts used is apparently harmless. Although most of the patients studied had incurable and rapidly fatal diseases, 47 of the patients are known to be alive and in remarkably good condition months and years after the injection. Some of them have lived more than four years. A number of them have cirrhosis of the liver, but clinical studies including the bromsulphthalein test of liver function have showed remarkably little progression in the severity of the disease in most cases. The patients have showed no increased susceptibility to infection.

The thorium dioxide is eliminated very slowly. The shadows in the roentgenograms due to its presence in the liver and

spleen show very little reduction in density after three and four years. However, after a variable length of time, usually more than two years, there may be evidence of mobilization from the fixed reticulo-endothelial cells of the liver and spleen to the lymphatics of these organs and to adjacent lymph nodes.

A preliminary histopathologic study of 71 cases indicates that the presence of the thorium dioxide has not caused appreciable organic changes.

It is predicted that hepatosplenography with stabilized thorium dioxide sol will come to be recognized as a valuable and essentially harmless diagnostic procedure.

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TABLE I—GIANT-CELL TUMOR OF BONE

Name Date	Sex Age	Region	Duration	Pathology	Operation	Recurrence	Metastasis	Radiation	Symptom free
B 1920	F ?	Sup maxilla left	2 years	Giant-cell tumor	Exploration and curettage 3 weeks before	No	No	Radium around the region	Well, 16 years
R 1921	F ?	Sup maxilla left	6 months	Giant cell tumor	Exploration and curettage twice	Yes Once	No	Radium, x-ray	Lost track of
K 1924	M 18	Right radius lower end	6 months	No	No	No	No	X-ray	Lost track of
B 1924	M 26	Sacrum inner surface	12 years	No	No	No	No	X ray, 1 series	5½ months later free from pain mass smaller. Lost track of
R 1924	M 14	Left first metatarsal	2 years	Giant-cell tumor	Yes, biopsy	No	No	X ray, 1 series	Well
W 1926	M 44	Lower right fibula	3 weeks	No	No	No	No	X ray, H V, 3 series	One and one half years later. Lost track of since
W 1927	F 34	Right lower radius	4 months	Giant cell tumor	Explored and curetted, did not wait for x-ray effects	No	No	Ptc op. x ray, 1 series	Well, 9 years
K 1929	M 25	Right first metacarpal	1 year	No	No	No	No	X ray, 2 series	One year. Lost track of since
J 1931	F 7	Right malar bone	3 months	Giant cell tumor	Biopsy	No	No	X ray, 2 series H V 1, S V, 1	Well 5 years
H 1935	M 5	Left upper humerus	3 months	Giant-cell tumor	Curettage, had pathologic fracture	No	No	X ray, 1 series	Well 9 months

To the novice this indicates activity on the part of the tumor, when in reality it means rapid central liquefaction of the tumor which may be followed by a pathologic fracture in the weight-bearing bones. This has been termed the "negative phase", it passes off in a few weeks and then calcification is slowly accomplished. Those patients who have recurrences after previous curettage and cauterization show a slower response than do the primary group. The explanation of this is not clear but it probably is due to a disturbed vascularity. Table I gives our experience with radiation in this type of tumor.

*Bone cysts* are strictly not bone tumors, but when no biopsy or exploration has been done they may be confused with giant-cell tumors. They show little, if any, response to irradiation. However, such lesions recur after surgery and cauterization and in instances of this kind irradiation is of value in preventing recurrences. The following history is of interest.

A N, aged 5 years, was referred to us in August, 1933, by Dr Harold Crowe, of the Orthopedic Hospital. Two weeks previously he had had his third operation on a bone cyst of the femur. Following a total of 1,200 r, which was given through three ports in two weeks' time, the area calcified. A recent letter from Dr Crowe states that the patient has now been well three years following the irradiation given him.

# RADIATION THERAPY OF BONE TUMORS<sup>1</sup>

By ORVILLE N MELAND, M D , *Los Angeles, California*

From the Oncologic Service of Dr Soiland, Dr Costolow, and Dr Meland, Los Angeles

IRRADIATION as a therapeutic agent has been used for bone tumors since radiation was first introduced into practice, but like many forms of medication its early use was purely empiric. As time has gone on, we have learned more and more about its effects so that we now have a fair idea as to what to expect when used in the various types of bone lesions. Experience has shown that in such a condition as giant-cell tumor its use alone results in a high percentage of permanent cures, while in other tumors, such as osteogenic sarcomas, the incidence of five-year curability is so low that it must be considered as a supplementary measure to surgery rather than a replacement procedure. Our knowledge along these lines has been accomplished by greater accuracy in diagnosis and our greater appreciation of radiosensitivity. Cells differ in their response to irradiation: those that disappear promptly with minimal dosages we term radiosensitive, while those that fail to show any change to amounts that are detrimental to the covering skin are termed radioresistant. It is apparent that many tissues fall between these two extremes, consequently response is determined by differential effects on cell types that make up the bulk of the tumor. It is easy to conceive that such terms as "radiosensitive" and "radioresistant" must be purely relative and have their basis in morphologic studies. Therefore, accuracy of histologic diagnosis is an absolute essential in the correct estimation of what may or may not be accomplished by irradiation. Biopsy material must then be the basis for such an opinion. The method of doing this, whether by aspiration or open operation, is a question to be decided by the

clinician, an important point to remember is that the material obtained be sufficient for the pathologist to make a thorough study on which to give his opinion. Even under such conditions the diagnosis may still be in doubt. Here it is justifiable to resort to the therapeutic test of radiation and the noting of its effect which may point the way to a correct diagnosis. In deed, it was not alone by histologic and radiologic studies but by radiation response that Ewing was able to place endotheliomas in a class by themselves. With this brief introduction we shall discuss the response and results obtained in the treatment of the many types of bone tumor.

Bone tumors are benign and malignant. In the benign class we have osteochondromas, giant-cell tumors, and bone cysts.

*Osteochondromas*, or exostoses, are of no importance from a radiotherapeutic standpoint since they show no response. They are a surgical problem and are of interest to the radiation therapist only when they undergo sarcomatous changes. When this happens their response is similar to the chondrosarcomas.

*Giant-cell tumors* are relatively sensitive to radiation. Not all are equally so, since this is a tumor of many variants, some contain cartilage, while others have xanthomatous elements, and at times one is malignant. Our experience, as well as the experience of others, points to the fact that the treatment should be moderate in amount and should be given in two or three series spread over a period of at least a year. In other words, the aim is to produce a slow sclerosis and calcification in a benign tumor. On the other hand, high doses rapidly given as is done in malignant conditions may be followed by a sudden increase in the size of the tumor, with redness of the skin, local temperature, and aggravation of the pain already present.

<sup>1</sup> Read before the Radiology Section of the California Medical Association at the Sixty fifth Annual Session Coronado May 25-28 1936

TABLE III—EWING'S TUMOR

Name Date	Sex Age	Region	Duration	Pathology	Operation	Recurrence	Metastasis	Radiation	Symptom free	Dead After
M 1921	M 24	Left femur	6 months	Sarcoma	Local excision	?	Chest	Radium, x-ray		3 years
A 1923	M 40	Left femur	2 months	Medullary sarcoma	Local excision twice	Yes	?	X-ray p o *	Lost track of	Lost track of
R 1925	M 34	Left femur	1 year	Ewing's	Amputation u p p c r third of thigh after x ray therapy	No	?	X ray, H V, 4 series over 3 years		
A 1928	R 24	Left os calcis	4 years	Small round cell Ewing (?)	Exploration 4 years ago, curettage, re- fused amputation	Yes	Yes Lungs, latc	X-ray close- where, ra- dium inscrted into cavity by us		10 years, no local re- currence 8 years, chest meta- stasis
R 1930	M 36	Lower femur	4 years	Ewing's	Curetted out twice— first time in 1926	Yes	?	X-ray close- white, 2 series	Lost track of, examined but not treated by us, dead now	
P 1930	R 24	Left femur	?	Ewing's	Exploration, insertion of platinum radium needles	No	Yes	X-ray, H V, 1 series		6 months
D 1933	R 11	Left hum	7 months	Ewing's	Exploration for osteo- myelitis	Yes	Yes Lungs	X-ray, 1 series, Coley's serum		6 months

\* P. o. = post operative

sensitive of all bone tumors, which is one of its diagnostic characteristics, as was mentioned earlier in the paper. It may disappear completely after irradiation, but in the majority of instances the effect is temporary, recurrence follows and distant metastasis is the rule. We have records of seven cases, two of whom passed the five-year period, but both patients died of the disease later. In all patients of the group there was histologic verification, the appended chart gives the end-results (See Table III).

*Multiple myeloma* is very sensitive to radiation and may be controlled for a limited period, however, the disease is so generalized that the possibility of cure is out of the question. We have not seen any case carry on longer than a year after the most carefully administered radiation.

*Osteogenic sarcoma* includes three varieties: sclerosing osteogenic sarcoma, osteolytic sarcoma, and periosteal fibrosarcoma. As a class, they are all extremely resistant to radiation. There may be temporary regressions, followed by marked relief from pain, but after a time growth increases and pain returns. Of the various groups mentioned, the periosteal fibrosarcoma seems to respond the best. A perusal of the literature indicates that there are cases treated by irradiation alone that have passed the five-year period. These must be looked upon as exceptions to the general rule, since the great percentage of cures obtained are by surgery alone or surgery combined with radiation. In our records we have four who have lived from 10 to 15 years after the diagnosis was made, all treated by surgery and radiation, none treated by radiation alone. Table IV gives the details of all cases we have seen.

*Hemangio-endothelioma of bone*, blood vessel tumors of bones, have a varying degree of sensitivity, as do angiomas in other localities. Usually

TABLE II—CHONDROSARCOMA

Time date	Sex Age	Region	Duration	Pathology	Operation	Recurrence	Metastasis	Radiation	Symptom free	Dead After
C 1918	M ?	Ilium	8 years	None	No	No	No	Many series x-ray—con- trols pain	For 26 years—at present has diffi- culty in getting around	
M 1923	M 38	Head left femur	13 years	None	No	No	No	X ray, 2 series H V, 1923, S V, 1935	13 years	
T 1926	M 15	Lower end right femur	3 months	Chondrosarcoma	Exploration	?	?	Radium buried in mass	Lost track of	
H 1927	M 30	Sixth rib right side at chondro cos- tal junction	2 years	None	No	?	?	Radium pack	Lost track of	
M 1929	F 37	Left ilium	6 months	Chondrosarcoma	After x-ray therapy chiselled off part of growth twice	Yes		X-ray, H V, 5 series		4 years
M 1930	M 50	Cervical vertebra	1 year	None	No	No	No	X-ray 3 series H V, 2, S V, 1	6 years	
R 1934	M 52	Left femur at ace- tabulum	2 years	None	No	No	No	X ray, 2 series		
B 1935	M 57	Right ilium	4 years	Chondrosarcoma	Three operations at Mayo Clinic Fourth done	Yes	No	Radium needles inserted at fourth opera- tion S V x-ray series	1 year	

In the malignant group of bone tumors we have chondrosarcomas, endothelial myelomas, multiple myelomas, osteogenic sarcomas, hemangiomas, and metastatic tumors

*Chondrosarcomas* are slow-growing tumors that tend to remain localized. They contain a mixture of chondromatous and myxomatous elements and are only moderately sensitive to radiation. Under this form of therapy the rate of growth may be controlled in some patients over varying periods of time, and the associated pain may be definitely diminished or stopped. However, in other instances the tumor continues to grow slowly and progressively even under massive doses of surface radiation. In such cases it is best to resort to a combined surgical and radiation attack, as advocated by Handley. The bulk of the tumor is chiselled away and the entire operative field is implanted with platinum radium needles. Under such a régime, the growth is checked, but the treatment is followed by slow healing and multiple discharging sinuses that require prolonged dressings because of the exfoliation of cartilaginous and bony sequestra. Our records contain the histories of eight patients in this class, some of whom have had x-ray treatment alone, while in others there has been a combination of surgery and radiation. The accompanying Table II shows the results obtained.

*Endothelial myeloma of Ewing* is the most radio-

	M	Right lower femur	10 months	No	No	No	Yes Groin	X ray 3 series	2 years
A 1026	59	Right tibia	3 weeks	No	Exploratory	No	Yes Groin	X ray, 1 series	6 months
C 1027	7	Right upper femur	?	No	No	No	No	X ray, 1 series	Lost track of
W 1027	46	Right hum	4 years	Sarcoma	Exploratory	No	Yes Groin and neck	X ray, 3 series	2 years
L 1027	56	Right mandible	7 years	Sarcoma	Exploratory and curettage 5 times	Yes	No	X-ray, radium	One and one half years, lost track of
M 1028	31	Left lower femur	2 years	Spindle-cell sarcoma	Exploratory and curettage	Yes	Yes Vulva	X ray, 2 series, radium, Coley's serum	1 year
L 1029	30	Right side hum	4 months	Periosteal sarcoma	Exploratory	Yes	Yes	X ray, 2 series lead, Coffey-Humber	6 months
I 1029	33	Left lower femur	6 months	No	No	No	Yes Groin	X ray, 1 series	6 months
R 1030	58	Right lower femur	6 months	No	No	No	Yes Chest	X-ray, 1 series	6 months
T 1030	60	Right scapula	3 months	No	No	No	No	X ray, 1 series	6 months
S 1030	73	Right lower femur	7 weeks	No	No	No	No	X ray, 1 series	Lost track of, probably dead
R 1030	15	Left lower femur	5 months	No	No	No	Yes Chest	X ray, 1 series, Coley's serum	1 year
E 1030	14	Left parietal	6 months	Sarcoma	Exploratory	Yes	Yes Check	X ray, 1 series	Lost track of
D 1030	33	Left clavicle	4 months	No	No	No	No	X ray, 1 series	1 year
L 1031	72	Right upper femur	8 months	No	No	?	?	X ray 1 series	Lost track of
J 1032	33	Left lower femur	4 years	No	No	No	Yes Inguinal nodes, chest	X ray, 3 series for 2 years by others, 1 series, S V, by us	6 months
S 1034	73	Left upper humerus	3 months	No	No	No	?		10 months
L 1034	23	Left lower tibia	2 months	Periosteal sarcoma	Exploratory	Yes	Yes Chest, groins	X ray, 3 series	9 months
H 1035	14	Right lower femur	?	Osteogenic sarcoma	Exploratory	Yes	Yes Groins	X ray, 2 series	1 year

P o = post operative

On reviewing these slides, it is seen that this case is probably a benign tumor, possibly a giant cell tumor



TABLE IV — OSTEOGENIC SARCOMA

Name Date	Sex Age	Region	Duration	Pathology	Operation	Recurrence	Metastasis	Radiation	Symptom- free	Dead After
S 1921	F ?	Head right humerus	2 years	No	No	?	?	Radium		?
M 1921	M 13	Left femur	2 months	Sarcoma	Exploratory	No	No	Radium into wound, p o X-ray	15 years	
P 1922	M ?	Right upper humerus	6 weeks	No	No			X-ray		8 months
B 1922	M 15	Left femur lower third	4 months	Sarcoma	Exploratory and curet- tage, amputation	?	?	Radium into wound, X-ray pre- and post- op		9 months
H 1922	M ?	Left ischium	2 years	Sarcoma	Exploratory	?	?	P o X-ray	14 years	
K 1922	M 20	Right femur upper third	2 months	Sarcoma	Local excision and curettage twice	Yes	?	P o X-ray	14 years	
M 1922	F 13	Left tibia	6 months	Sarcoma (low grade) on bi- opsy	Amputation, 1928 Found no malignancy in specimen	No	?	Three series X-ray over 3 years before amputation	1932 well 10 years†	
E 1923	F 13	Left scapula	2 months	Sarcoma	Exploratory	No	No	X-ray	Lost track of	
G 1923	F 14	Left occiput	?	Sarcoma	Local excision	Yes	Yes	P o X-ray		2 months
M 1923	M 6	Right femur lower end	6 weeks	Osteosarcoma	Local excision and curettage	?	?	P o X-ray		
L 1924	M 33	Coccyx	6 months	Sarcoma	Removal of tumor	?	?	P o X-ray 2 series		6 months
S 1924	M 40	Third rib right side	1 year	Sarcoma	Local excision twice	Yes	?	P o X-ray		Yes
O 1925	I 50	Right pubic bone	1 and one half years	No		?	?	X-ray		1 year
A 1925	M 45	Left femur upper third	4 months	No	No	?	?	X-ray		6 months
K 1925	I 50	Left humerus upper third	6 months	No	No	?	?	X-ray	Lost track of probably dead	
G 1925	M ?	Right lower femur	1 year	No	No	?	?	X-ray	Lost track of	
McI 1925	M 35	Right upper humerus	1 year	No	No	No	No	X-ray, 1 series	Lost track of	
O 1926	M 45	Left femur	2 and one half years	Perosteal sarcoma, autopsy	No	No	Yes Lungs Yes	X-ray 2 series collodial lead		9 months
R 1926	M 21	Left upper humerus	4 and one half months	Sarcoma	Exploratory	Yes	Yes	X-ray 1 series		8 months

A	M	Right lower femur	10 months	No	No	No	Yes Groin	X ray 3 series	2 years
1926	59	Right tibia	3 weeks	Spindle cell sarcoma	Exploratory	No	Yes Groin	X ray 1 series	6 months
C 1927	7	Right upper femur	?	No	No	No	No	X ray 1 series	Lost track of
W 1927	M 40	Right ilium	4 years	Sarcoma	Exploratory	No	Yes Groin and neck	X ray, 3 series	2 years
L 1927	M 56	Right ilium	7 years	Sarcoma	Exploratory and curettage 5 times	Yes	No	X ray, radium	One and one half years, lost track of
M 1928	M 31	Right mandible	2 years	Spindle cell sarcoma	Exploratory and curettage	Yes	Yes Vulva	X-ray, 2 series, radium, Coley's serum	1 year
L 1929	I 30	Left lower femur	4 months	Periosteal sarcoma	Exploratory	Yes	Yes	X ray, 2 series, lead, Coffey-Humber	6 months
I 1929	M 33	Right ilium	6 months	No	No	No	Yes Groin	X ray, 1 series	6 months
R 1930	M 58	Left lower femur	6 months	No	No	No	Yes Chest	X-ray, 1 series	6 months
T 1930	I 60	Right lower femur	3 months	No	No	No	No	X ray, 1 series	6 months
S 1930	M 73	Right scapula	7 weeks	No	No	No	No	X ray, 1 series	Lost track of, probably dead
R 1930	M 15	Right lower femur	5 months	No	No	No	Yes Chest	X ray, 1 series, Coley's serum	1 year
E 1930	M 11	Left lower femur	6 months	Sarcoma	Exploratory	Yes	Yes Chest	X ray, 1 series	Lost track of
D 1930	F 33	Left parietal	4 months	No	No	No	No	X ray, 1 series	1 year from heart attack
L 1931	F 72	Left clavicle	8 months	No	No	?	?	X ray 1 series	Lost track of
J 1932	F 33	Right upper femur	4 years	No	No	No	Yes Inguinal nodes, chest	X ray, 3 series for 2 years by others, 1 series, S V, by us	6 months
S 1934	M 73	Left lower femur	3 months	No	No	No	?	X-ray, 3 series	10 months
L 1934	M 23	Left upper humerus	2 months	Periosteal sarcoma	Exploratory	Yes	Yes Chest, groins	X-ray, 3 series	9 months
H 1935	F 14	Left lower tibia	?	Osteogenic sarcoma	Exploratory	Yes	Yes Groins	X ray, 2 series	1 year
L 1935	M 60	Right lower femur							

\* P o = post operative

† On reviewing these slides, it is seen that this case is probably a benign tumor, possibly a giant cell tumor

TABLE V—HEMANGIOMA OF BONE

Name	Sex	Age	Region	Duration	Pathology	Operation	Recurrence	Metastasis	Radiation	Symptom-free	Dead After
W 1928	F	32	Twelfth dorsal vertebra	6 years	Hemangioma	Exploratory, 2 years ago	No	No	X-ray, 3 series	Yes, eight years since beginning	
W 1931	F	37	Head of left humerus	1 year	Hemangioma, aspiration biopsy verified at autopsy	No	No	Yes Skull	Three series 1 H V, 2 S V		Three years
D 1932	M	50	Right sup max illa	6 months	Hemangioma	Yes, electrocoagulation, complete destruction of right antrum	Yes	No	X-ray, radium		One and one-half yrs, extension to brain

the younger the patient the more sensitive the tumor, but this alone is not a reliable point since these tumors may also have an abundance of endothelial elements that may or may not be sensitive. Our experience is limited to three cases. The initial response is very encouraging, but recurrence and metastasis is the rule. (See Table V)

*Metastatic bone tumors* are secondary to growths arising in many organs. The thyroid, breast, prostate, and kidney harbor the primary tumor in the majority of instances, however, any organ may be the offender. Under irradiation such metastatic tumors may show complete regression and calcification. The relief from pain is striking and the individual may be restored to full activity, but eventually death comes from involvement of the lungs or liver. Every radiologist has records of such cases in his files. The case given below was reported by my colleague, Dr. Soiland.

Mrs. F., aged 40 years, came in with metastasis over the left chest and axilla following the radical removal of her left breast for carcinoma five years previously. The metastatic areas were subjected to intense x-radiation and in due course completely disappeared. One year after this treatment the patient developed pain, with restricted motion, in the left hip. She lost weight and became cachectic. Morphine was used and she was bedridden because of destructive metastasis in the left ilium and the sacrum. Under x-ray therapy the lesions disappeared, and within a month she was up, her pain had disappeared, and she had gained 30 pounds in weight. She considered herself well. Two years later she took a trip to Europe where, among other things, she climbed the Alps. She continued in good health for two years longer, then became bedridden with liver metastasis from which she died. This patient had her life prolonged three and one-half years, carrying on a normal existence and remaining well until a few weeks before her death.

*Technic*—Radiation therapy of bone tumors has been going through an evolutionary phase, due to changes and improvements in apparatus. No two men have had the same idea as to the proper dosage, since some have used low voltage x-ray, some high voltage, some radium packs and bombs, and now we have the supervoltage x-ray. We have used all methods, and so far we have not seen any great or radical improvements in clinical results for the reason that tumors which are not sensitive to lower voltages have not been influenced to any greater extent by

supervoltages With the extended use and application of the principles of Coutard's protracted method of irradiation, the question arises, "Will prolonged heavy irradiation give any better results?" With the possible exception of Ewing's tumor, we doubt that it will result in any increase in curability—certainly our experience in chondrosarcoma bears this out Pain is diminished but growth is invariably slow and steady However, we feel that it is too early to give a final opinion, furthermore, one must remember that prolonged heavy radiation may lead to radiation osteitis, a chronic disabling condition in itself Likewise, it must not be forgotten that heavy treatment administered to the epiphyseal cartilages in the growing individual does result in atrophy and permanent deformity from destruction of the epiphyseal centers

Should multiple ports be used as advocated by Desjardins? When apparatus was less powerful it was necessary to resort to such a method, but with higher voltages insuring greater dosages in the tumor itself, it seems to us that multiple ports are not now so necessary Depending on the location of the tumor, especially if it is in an extremity, it is our usual procedure to give treatment through two or possibly three ports, using 200 kv, 4 ma current, 50 cm distance, 0.5 mm Cu + 1 mm Al filter, giving from 200 r to 300 r per port per day To the giant-cell tumor we give a total of from 600 r to 800 r per port, after which the patient is not treated for three or four months, when a similar series may be repeated In other words, we use moderate doses, repeat the series, and wait for the effects over a year or more In the malignant bone tumors, a similar method of attack is used except that the filter is increased to 1 mm Cu so that the dosage is increased up to from 1,200 r to 1,600 r per port, treating the patient daily Even under this procedure the effect is usually only temporary With supervoltages up to 500 kv and a filter of 4 mm brass and 0.5 mm Pb, an equivalent of 13 mm Cu, we have given up to 3,000 r per port, but

even this may not control the growth in osteogenic sarcomas Even in cases in which growth is controlled, metastasis has taken place that brought death to the patient

In cases in which radium was used in the operative field, the technic has also changed Fifteen years ago a 50 mgm tube filtered through 1 mm brass and 1 mm rubber was packed in the wound At present we have turned to highly filtered containers, using platinum needles containing 1 or 2 mgm of radium with a filtration of 0.5 millimeter

*Discussion*—Giant-cell tumors many times are permanently cured by x-radiation Surgery also cures these neoplasms The question of the method to use must rest to a large extent with the patient If he or she is willing to wait for radiation effects, then x-ray therapy may be advised On the other hand, if for economic reasons the patient wishes a quick result, then surgery or cauterization is better In cases in which one of the methods is followed by failure, resort can be had to the other

In the report of the Registry of Bone Sarcoma sponsored by the American College of Surgeons, we find that they have records of 80 patients suffering from osteogenic sarcoma (including Ewing's tumor), who have passed the five-year period Of these, 42 were cured by surgery alone, 35 by a combination of surgery and some form of irradiation with or without Coley's toxins, and three by radiation alone While such a report is meager and does show progress in a condition formerly looked upon as hopeless, it gives only one side of the question The number of patients not responding to any kind of treatment is omitted The percentage of absolute cures must be relatively low The nature of this tumor is such that metastasis often has taken place before the first consultation Sometimes this metastasis shows up anywhere from a week to six weeks after the most carefully executed operation, so that the early appearance of metastasis is sometimes attributed to the manipulation incident to the operation it-

self Whether or not such a theoretical question is true is difficult to answer, but possibly a change in technic may improve results Though the rate of cure with radiation alone is low, this does not mean that many cells are not affected and that it should be abandoned Disregarding the matter of professional and lay education and early diagnosis, whatever improvements take place must be along radiological and chemical lines, as surgery has reached its limit when amputation or curettage is resorted to Few patients die of local recurrence, knowing this, and also knowing the extreme resistance of such tumors to radiation, would it not be justifiable to revise our attack? Give massive  $\lambda$ -radiation over the tumor and along the shaft to the level of amputation, to the limit of tissue tolerance, or get radiation effects from the insertion of multiple platinum radium needles around the lesion before amputation The latter method is used in infected massive epitheliomas of the tongue prior to removal by electrocoagulation, with recovery in some apparently hopeless cases

What shall be done in cases in which the patient refuses amputation or when removal is not possible surgically? Granting that the pathologic diagnosis was correct, we have three patients still living on whom

only an exploratory or a conservative local excision was done In one, radium was used, and in the others post-operative  $\lambda$  ray The surgery was really done to establish the diagnosis In those patients in whom radium is used in the wound, the dosage must be gauged by the tissue examined Here the same problem presents itself as in chondrosarcomas, a discharging sinus which requires prolonged dressings may result In post-operative treatment with x-rays the dosage must be limited since a breaking down of the wound may result, and osteitis with fracture may take place This is especially true in cases in which prolonged radiation may be attempted, but this must not be considered a contra-indication

*Summary*—Radiation therapy has a definite place in the treatment of bone tumors In giant-cell tumors the results are good, while in some chondrosarcomas the results may be discouraging when used alone The combined use of surgery and radium needles offers the patient a great deal for permanent cure In osteogenic sarcomas and Ewing's tumor, radiation must be looked upon as an ancillary to surgery when cure is considered, but in the case of the inoperable patient and the one with metastasis, radiation is advisable to relieve pain and prolong life by growth control

# THE GLIOMAS ROENTGENOLOGICALLY CONSIDERED

By CHARLES WADSWORTH SCHWARTZ, M D, *New York City*

From the Department of Radiology, Neurological Institute of New York

IN order to be able intelligently to consider the gliomas from a roentgenologic viewpoint, we should first review briefly our present beliefs regarding the origin of these tumors and their development as pathologic entities. There are still differences of opinion as to the origin and classification of the gliomas, but it seems fairly safe to say that they originate from brain tissue which in some way has been stimulated to abnormal growth. There are many theories regarding the origin of gliomas which have been suggested from time to time by such well-known authorities as Cohnheim, Samuel, Monakow, Pfleger, Bailey, and others. Pfleger, as quoted by Bailey, has shown that in 75 out of 400 cerebellums that he studied he was able to find incompletely differentiated cells close to the roof of the fourth ventricle, which is a common site for the development of the medulloblastomas. This is a rather suggestive finding. Cohnheim's theory attempts to explain the origin of the gliomas from undifferentiated cells, but del Rio Hortega has shown that in many instances in which undifferentiated cells were thought to be present, actually the cells were quite well developed.

It seems highly probable that the origin of the gliomas is not essentially different from the origin of tumors elsewhere in the body, and that they arise from some "anlage" composed of cells capable of unrestricted growth when subjected to a suitable stimulus. If this is true, then we must conclude that these tumors are potentially present at birth in those persons who eventually develop such lesions. As a corollary to this assumption, we might be tempted to suggest radiotherapy for all, after the brain has become completely developed, in the hope that the tumor anlage is radiosensitive. We know brain tissue is extremely

radioresistant so that such radiation would be harmless, and any harmless procedure which might reduce the prevalence of brain tumors would certainly be worth considering.

Many attempts have been made to classify the gliomas according to the cell types of which they are composed. Certainly one of the most successful of these efforts was that of Bailey and Cushing whose classification is, I believe, the most widely accepted of any to date. Briefly, their schema traces the development of the various tumors from the original medullary epithelium through the many cell differentiations, each giving potential origin to a particular type of tumor, and finally to the highly differentiated portions of the brain from which other types of tumors arise. This is well portrayed in Figure 1, from this chart it can be seen how the rather formidable nomenclature of the gliomas has been devised.

Before considering these tumors individually, it might be well to point out that brain tumors are by no means as uncommon as some are wont to believe. In fact they are exceeded in frequency only by tumors of the uterus, breast, and stomach, and the gliomas constitute about 45 per cent of intracranial newgrowths. Hence it would hardly be amiss to take this opportunity to urge that all cases of intractible headaches, including migraine, and certainly those showing impairment of function of any of the cranial nerves, be studied as possible cases of intracranial tumor, and given the benefit of a careful radiographic examination.

In searching for evidences of intracranial pathology one should bear in mind that poor films are a distinct liability. Technically poor films and those that are not stereoscopic will not only fail to show signifi-

self Whether or not such a theoretical question is true is difficult to answer, but possibly a change in technic may improve results Though the rate of cure with radiation alone is low, this does not mean that many cells are not affected and that it should be abandoned Disregarding the matter of professional and lay education and early diagnosis, whatever improvements take place must be along radiological and chemical lines, as surgery has reached its limit when amputation or curettage is resorted to Few patients die of local recurrence, knowing this, and also knowing the extreme resistance of such tumors to radiation, would it not be justifiable to revise our attack? Give massive x-radiation over the tumor and along the shaft to the level of amputation, to the limit of tissue tolerance, or get radiation effects from the insertion of multiple platinum radium needles around the lesion before amputation The latter method is used in infected massive epitheliomas of the tongue prior to removal by electrocoagulation, with recovery in some apparently hopeless cases

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*Summary*—Radiation therapy has a definite place in the treatment of bone tumors In giant-cell tumors the results are good, while in some chondrosarcomas the results may be discouraging when used alone The combined use of surgery and radium needles offers the patient a great deal for permanent cure In osteogenic sarcomas and Ewing's tumor, radiation must be looked upon as an ancillary to surgery when cure is considered, but in the case of the inoperable patient and the one with metastasis, radiation is advisable to relieve pain and prolong life by growth control

edema may produce a considerable elevation of intracranial pressure even though there be no definite block of the cerebral fluid pathways. The history of such a tumor is usually abrupt and malignant, and, practically speaking, operative interference is merely palliative. This is as might be expected because it is impossible in most cases macroscopically to determine where tumor-invaded tissue ends and normal cerebrum begins.

The glioblastoma multiforme is a rapidly growing tumor so that its course is usually too short to permit of much calcification taking place, but in many of these cases calcification is visible in the roentgenogram. The deposit is usually in the degenerated portion of the tumor, and although it has no characteristic configuration it is very apt to be amorphous, but the string-like and punctate forms also may be found. Due to the expansive characteristic of this form of glioma, the pineal gland is frequently displaced away from the lesion and signs of increased intracranial pressure may or may not be evident. Usually by the time an x-ray examination is considered advisable, the symptoms are rather well marked, so that evidence of intracranial disease may often be seen, such as atrophy of the dorsum sellæ and posterior clinoid processes. The recognition of atrophy of these structures depends chiefly upon the condition of the bony cortex, for it must be borne in mind that a hypocalcemia may produce a marked halteresis of the bones of the base, but the cortex will be intact.

Briefly then, the recognition of the presence of a glioblastoma multiforme depends upon a short malignant history, the recognition of evidences of intracranial disease such as a displaced pineal gland, atrophy of the structures forming the sella turcica, and occasionally signs of generalized increased intracranial pressure with atrophy of the inner table of the calvarium, and a "fuzzy" deepening of the convolutional digitations. Calcification when present may be large or small in extent, and any shape, but it is likely to be amorphous.

Untreated, these tumors result fatally



Fig 2 Calcification in a glioblastoma multiforme. There are no signs of increased intracranial pressure which are so frequently lacking in presence of this type of glioma.

within about a year, and as a rule surgery offers but a few additional months. Radiotherapy is also disappointing, but with the application of from 2,500 to 4,000 r units in divided doses, the survival time may in some cases be boosted to as much as double that expected, with an occasional remission of symptoms so that the patient may regain a short period of usefulness. I feel convinced that the tumor cells are altered by x-radiation, and that evidently the so-called "law" of Bergonié and Tribondeau holds for the gliomas. We have still to determine the lethal dose for the various forms of brain tumors, and a study of the growth and metabolic characteristics of these tumors will be necessary before we can accurately predict whether the divided or massive dose technique will be the method of choice, and in fact determine whether the lethal dose for a glioma cell is really less than it is for normal glial tissue.

Another common type of glioma is the astrocytoma, which constitutes about 30 per cent of the glioma group. This form of tumor may be subdivided into the protoplasmic, fibrillary, and mixed varieties, but for the purpose of this discussion such a



cant changes but may give false evidence which is equally disconcerting. It has always been my conviction, and still is, that

One of the most common of the gliomas is the glioblastoma multiforme or spongioblastoma multiforme, as it is often termed

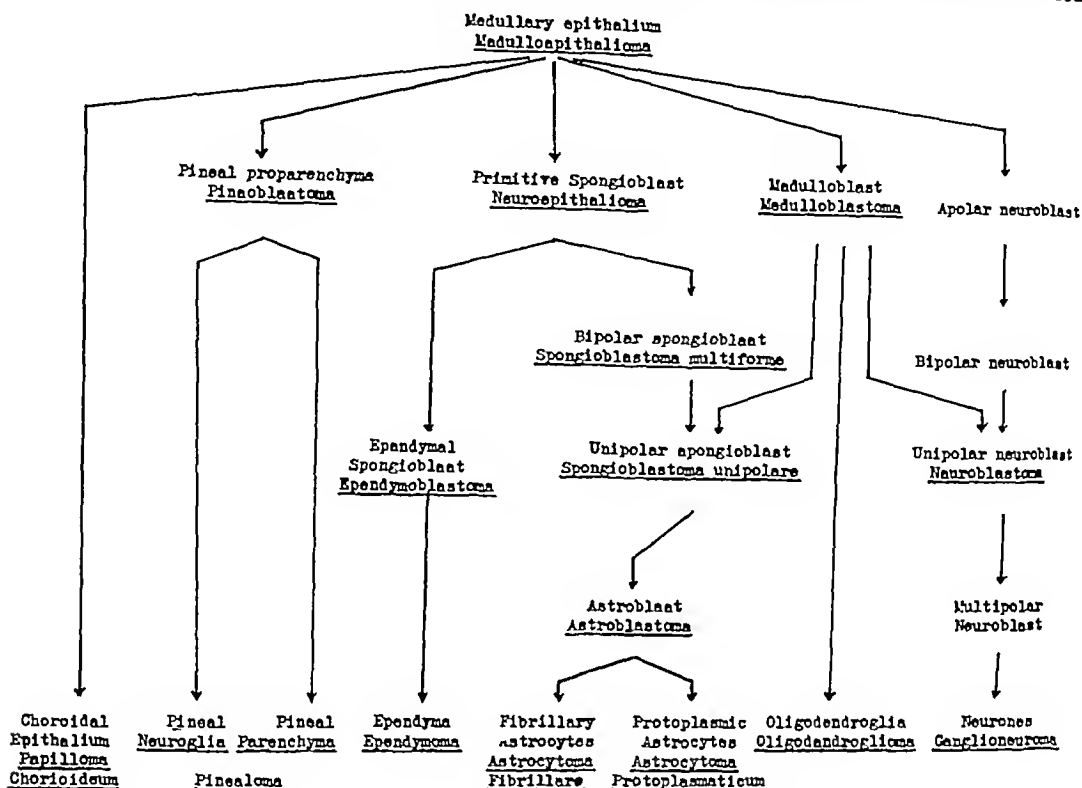


Fig 1 From Bailey and Cushing Tumors of the Glioma Group

a history of the case, together, if possible, with the clinical findings, should be available if one is to properly evaluate the shadows on the film. This, of course, presupposes the practice of strict intellectual honesty.

Through the kind permission of Dr Charles A. Elsberg, a search was made of the records of the Surgical Department of the Neurological Institute of New York covering the past ten years, and a group of several hundred cases, which were operatively proved gliomas and had had pre-operative x-ray examinations, were collected and analyzed for this discussion. Dr E. M. Deery, of the Surgical Department, was so kind as to allow me to study the descriptions of his recent microscopic findings regarding the effect of x-radiation on the gliomas. His conclusions are freely used in the evaluations to follow.

It is a tumor of the adult cerebrum and at one time was called a gliosarcoma, but as sarcomas are not of glial origin this soon was recognized as a misnomer. These tumors formed about 30 per cent<sup>1</sup> of all gliomas. As the name "multiforme" implies, the tumors are composed of a multitude of cell forms, some poorly differentiated, which often makes the microscopic recognition of such a tumor difficult. It grows rapidly and infiltrates widely, even crossing at times to the opposite hemisphere through the corpus callosum. Hemorrhages are apt to occur within the growth and cystic degeneration is not uncommon. The tumor is often expansive, which trait when coupled with the usual surrounding

<sup>1</sup> These percentages are a composite taken from the reports of several neurosurgical clinics. This I believe gives a more accurate general average than would be obtained by quoting the averages from this clinic alone.



Fig 5



Fig 6

Fig 5 Typical air study of a frontal lobe tumor. The frontal horns of the lateral ventricles are sharply cut off. Calcification can be seen in the frontal region which was in an astroblastoma.

Fig 6 Same case as Figure 5. Anteroposterior view showing the shift of the lateral ventricles to the right away from the site of the tumor.

type closely simulating that produced by a pituitary adenoma. There will also be present, if the tumor is large enough, general signs of increased pressure, such as atrophy of the inner table of the calvarium and deepened convolutional markings. If the pineal body is calcified it is very frequently displaced away from the site of the tumor. On very rare occasions a glioma may produce localized atrophy of the skull bones.

In summary, the roentgen diagnosis of an astrocytoma in a child depends upon a history of a few months of gradually progressive symptoms, signs of increased intracranial pressure, and little or no atrophy of the sella turcica. This, of course, is merely evidence of a tumor in the posterior fossa. In the adult we should have a history of many months, even years, of gradually progressing symptoms with perhaps remissions, signs of increased intracranial

pressure, a shift of the pineal body, atrophy of the sella turcica which may be marked, and string-like or punctate deposits of calcium usually situated in the temporal lobe or in the temporo-fronto-parietal region.

The post-operative radiation treatment of the astrocytomas is to be advised, but empirically so. If the operation has been complete there is no reason to expect recurrence, and perhaps some of our apparently brilliant results from radiation are due chiefly to a brilliant and courageous operation, again, normal remissions in the growth of this type of tumor are not unknown. It should be noted here that occasionally an astrocytoma will take on the growth characteristics of a glioblastoma multiforme through an apparent cellular transition. Radiation might stop the tendency to such a metamorphosis, it evidently does something to these growths which slows their growth, so that even with



Fig 3

Fig 3 Astrocytoma of posterior frontal region the one produced by a pituitary adenoma



Fig 4

Fig 4 Astrocytoma of the temporal region The calcification occurs in linear and punctate forms The sella turcica shows but little evidence of atrophy

divided classification will be unnecessary. The astrocytoma is a very slow growing tumor, in fact, it ranks as the slowest growing of all the gliomas, with the possible occasional exception of an oligodendroglioma. With relatively few exceptions, it is a tumor of the cerebrum of adults and the cerebellum of children. It might not be amiss to mention here that the majority of intracranial tumors of childhood occur below the tentorium.

This type of glioma is very apt to become cystic. This is especially true of those occurring below the tentorium, in which case the tumor may be found to be almost entirely cystic with only a small nubbin of tumor tissue attached to the cyst wall. The astrocytoma, like the glioblastoma multiforme, is an unencapsulated tumor, so that its exact extent in the surrounding brain tissue is difficult to determine at operation, but as the tumor is not at all vascular it can be attacked with considerable vigor, and not infrequently a complete removal will be possible. An astrocytoma occurring below the tentorium is most commonly found in one of the cerebellar hemispheres, although its origin occasionally may be traced to the vermis. Its site of election in the cerebrum is the temporal

lobe, however, the frontal and parietal lobes are not immune. It is of interest to note that the occipital lobe is a relatively uncommon site for any brain tumor.

An astrocytoma will not infrequently contain sufficient calcium to cast a shadow in the roentgenogram. This tendency to calcify is, of course, to be expected, due to its slow growth and degenerative characteristics. The calcium deposit will not be found in any characteristic form, but it is more likely to be seen as linear streaks or as punctate deposits which must not be confused with the deposits of calcium so often seen in the glomus of the choroid plexus on one or both sides. Its location can, of course, be closely estimated from the study of stereoscopic films. When the tumor occurs below the tentorium in a child it is not likely to calcify, and the only roentgen evidence of its presence will be the results of elevated intracranial pressure such as separation of the sutures and deepening of the convolutional impressions, but usually without much evidence of atrophy of the sella turcica. When the lesion is above the tentorium we usually find, in addition to the calcification when that is present, considerable atrophy of the sella turcica and even, at times, ballooning of a



Fig 5



Fig 6

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Fig 7



Fig 8

Fig 7 Oligodendroglioma of the frontal region. The deposit of calcium is both linear and flocculent. The sella turcica shows marked evidences of destruction which indicates that the tumor has been present for some time.

Fig 8 Calcification in an intraventricular tumor which was thought to be a papilloma both pre-operatively and at operation, but later pathologically diagnosed as an oligodendroglioma. Note the atrophy of the sella turcica but no other signs of increased intracranial pressure.

an operatively inaccessible tumor one should radiate vigorously. Due to the odd characteristics of growth of the astrocytoma, it is difficult to definitely evaluate any form of treatment, but apparently operation plus radiation may add many years to the patient's life.

The medulloblastoma is another common form of glioma but it possesses several unique characteristics. It was first adequately described by Bailey, and has since been found to constitute about 11 per cent of all gliomas. It is a tumor most frequently found in the posterior fossa of children of about nine to twelve years of age. The site of election for the medulloblastomas is close to, or involving, the roof of the fourth ventricle. These tumors are of rapid growth and have the unique tendency to spread widely through the leptomeninges, and cases have been seen in which they seem to have actually metastasized through the cerebrospinal fluid pathways. Such tumors may occasionally be found in young adults. Untreated, a patient with a medul-

loblastoma would not be expected to live more than about one year, often the course would be run in half that time. The tumor is rather vascular and solid, but due to its tendency to spread, its complete surgical removal is never successful.

The roentgen evidence of the presence of a medulloblastoma is usually the evidence of increased intracranial pressure only. Such a lesion rarely calcifies, in fact, so rarely that a deposit of calcium in the posterior fossa of a child should make one think, not of a medulloblastoma, but of an ependymoma or possibly an astrocytoma, a teratoid or a tuberculoma. The history will play an important part in making a differential diagnosis. The medulloblastoma will have a short malignant history which, of course, is not pathognomonic, but would at least be strongly suggestive.

The treatment of the medulloblastoma is rapidly becoming a non-surgical problem, provided a pre-operative diagnosis can be definitely made, because these tumors are remarkably sensitive to x-radiation. How-



Fig 9 (*left*) Some case as shown in Figure 8 after the injection of air showing the enlargement of the ventricles and the filling defects due to the presence of tumor tissue

Fig 10 (*middle*) Small deposits of calcium can be seen which are in a spongioblastoma polare The dorsum sellæ is slightly atrophic but otherwise there are no signs of an elevation of intracranial pressure

Fig 11 (*right*) The spotty deposits of calcium are in an ependymoma Note the general signs of increased intracranial pressure

ever, it is often advisable to operate first, merely making an occipital decompression, and, if possible, have a look at the tumor for purposes of diagnosis. An astrocytoma might produce identical symptoms, but if such a tumor were found it would, of course, be advisable to remove it immediately. Patients under intensive radiation therapy will often appear to have been completely cured as far as symptoms are concerned and remain so over a period of years. The treatment had best be in divided doses because massive doses to the posterior fossa are apt to aggravate the symptoms by producing some edema, and also I am rather inclined to think that, especially in children, heavy radiation to the posterior fossa may give rise to a form of "radiation sickness" not entirely the result of edema. The treatment of this form of glioma should not be confined to the apparent location of the tumor but should include the entire head and spinal cord, because of its tendency to widespread dissemination.

The astroblastoma is a rather rare form of glioma which is found almost without exception in the cerebrum of adults. It is a tumor which is clinically quite similar to the glioblastoma multiforme, but constitutes only about 5 per cent of the glioma group. These tumors grow with a rapidity which permits a life expectancy of about two

and a half to three years. Cystic degeneration is not uncommon but is much less common than in the glioblastoma multiforme. The tumors are not encapsulated and tend to invade surrounding brain tissue, so that at operation they are easily confused with the glioblastoma multiforme. The astroblastoma not infrequently calcifies. Histologically, the tumors are made up of embryonic astroblasts which tend to form themselves about blood vessels, and not infrequently the tumor will be found to contain spongioblasts and astrocytes, so that they are often classed as mixed tumors. The cells forming the astroblastomas occasionally contain mitotic figures.

To make a roentgenographic diagnosis of an astroblastoma would be practically impossible because these tumors are relatively uncommon, and, although they may calcify, the deposit is apt to be without distinguishing characteristics, and furthermore the history will strongly suggest a glioblastoma multiforme. There may or may not be evidences of increased intracranial pressure or a shift of the pineal gland. Air studies will be of no aid in a differential diagnosis but will merely show the presence of a tumor.

X-radiation would be expected to be of about the same efficiency in the treatment of an astroblastoma as it would be in the

treatment of a glioblastoma multiforme. The presence of mitotic figures in some of the astroblasts would, of course, suggest a moderate degree of radiosensitivity. The tumors should be treated because their complete surgical removal is rarely if ever accomplished. The treatment should be prolonged and vigorous.

The oligodendroglioma is a comparatively rare form of tumor constituting about 4 per cent of all the gliomas. It is a tumor found with but few exceptions in the cerebral hemispheres of adults of from forty to fifty years of age. This is rather odd when we consider the fact that the oligodendroglial cells are rapidly growing at and shortly after birth, but tumors do not develop until the cells are almost inert and practically homologous with the Schwann cells, however, they lose their propensities for rapid growth, for the oligodendroglioma is a very slow growing tumor, about on a par with the astrocytoma.

The tumors are solid, not apt to become cystic or degenerate, and although not encapsulated they are fairly well demarcated from the surrounding brain tissue. They are not very vascular and are rather prone to calcify. The calcification is usually found to be perivascular and, therefore, will appear in the roentgenogram as streaky or somewhat flocculent shadows. Operative success and survival periods for these tumors are quite comparable to those of the astrocytomas.

The recognition of an oligodendroglioma in the roentgenogram is usually very difficult because the changes seen and the history will be almost identical with the astrocytomas occurring in adults, and moreover as the astrocytoma is by far the more common tumor it is much more apt to be the correct diagnosis in any case of doubtful differentiation. However, if one sees a deposit of calcium which seems to be of a string-like type, probably following the course of blood vessels, which shows a flocculent, flaky configuration with or without pineal gland displacement or evidences of an elevation of intracranial pressure, in addition to a long, slowly progressive his-

tory perhaps covering years, one would be justified in making a highly probable diagnosis of an oligodendroglioma. It might be mentioned that in spite of the calcification being as a rule perivascular, it will not appear as double convoluted streaks such as are seen in the blood vessel anomalies.

Radiotherapy of these tumors is not as successful as might be expected, because there are very few cells which show mitotic figures, but, as in the case of the astrocytomas, it will slow the growth in case of incomplete surgical removal or inaccessibility. It is also a strongly advisable procedure because not infrequently when one of these gliomas recurs it does so in an altered and much more malignant and perhaps atavistic form.

The spongioblastoma polare is a tumor which occurs with about the same percentage frequency as the oligodendroglioma but it is very rarely found in patients much beyond the age of adolescence. It is very slow growing and has as its site of election the cerebral axis and brain stem. It is the most common form of glioma found involving the optic chiasm, and moreover, when found in this location it is frequently associated with von Recklinghausen's disease (neurofibromatosis). Occasionally one of these tumors will be found in the cerebellum of a child, and not infrequently one will be found in the pons, but in spite of the consequent enlargement of the pons the fourth ventricle will often not be compressed, so that there will be no increase of intracranial pressure. These tumors are solid, almost avascular, and usually show no cystic or degenerative changes, but they do occasionally contain deposits of calcium which can be seen in the roentgenogram. The recognition of the presence of a spongioblastoma polare in the roentgenogram is based upon several factors, depending upon the location of the lesion. If calcification were seen in a position close to the clivus and obviously in the pons with or without evidence of increased intracranial pressure, if the patient be young and the history long and slowly progressive, such a diagnosis would be highly probable. Calci-

fication near or about the clivus might be in a chordoma arising from the echordosis physaliphora, but such a tumor would be apt to have a more malignant and shorter history, and moreover, the chordoma is a rare tumor. The type of calcification is not characteristic.

Air injection studies in the presence of a tumor of the pons would be expected to show a posterior displacement of the fourth ventricle, which, of course, could be simulated by an aneurysm of the basilar artery, but the age of the patient would be against aneurysm as a diagnosis. On the other hand, a spongioblastoma polare of the optic chiasm would produce atrophy of the sella turcica which might involve the entire structure or, as is occasionally the case, the anterior clinoid processes would be chiefly involved with perhaps one showing the most atrophy. The optic canals often show enlargement and atrophy or destruction of the walls, with one, as a rule, showing the greater change. Rarely small deposits of calcium might be present in such a tumor which could be seen within the shadow of the enlarged optic canal. These tumors may extend far enough above the sella turcica to block the interventricular foramen, and so give rise to the signs of a general increase of intracranial pressure, with separation of the sutures and increased depth and number of the convolutional markings. Air studies not infrequently show a small filling defect or flattening of the cisterna chiasmatis. These changes in a child or young adult with or without neurofibromatosis would be strongly presumptive evidence of the presence of this type of glioma. Meningeal tumors might simulate these changes but the age of the patient would practically exclude such a possibility. Buceoneural pouch tumors should also be considered in a differential diagnosis, but they do not produce changes in the optic canals and they are apt to show calcification above or at the side of the sella turcica.

Radiotherapy is often the only form of treatment possible for a spongioblastoma polare, because its location usually makes it surgically inaccessible. X-radiation

would not be expected to be of much value in treating such a slowly growing tumor, which contains as few mitotic figures as this type of glioma does. In fact, with our present technic about all we can hope for is a slowing of the growth, but this does seem to be possible, so that perhaps a year or more may be added to the life expectancy of the patient.

The ependymomas constitute another group of tumors which are but little less common than the two types previously discussed. They form about 3 per cent of the glioma group. These tumors are of ependymal origin and occur in two forms, the ependymoma and the ependymblastoma, which can not be differentiated in the roentgenogram. They occur along the ventricular walls with a predilection for the fourth ventricle. The tumor is comparatively benign and were it not for its unfavorable location one might be present for years without giving rise to more than minor symptoms, but a tumor of or in the fourth ventricle soon becomes a menace to life and calls for vigorous action. The ependymomas often occur in children and not infrequently calcify sufficiently to cast a shadow in the roentgenogram. It might be of interest to mention that this form of tumor is among the most frequently found in the spinal cord.

The roentgen diagnosis of an ependymoma is dependent upon the finding of evidences of increased intracranial pressure with or without atrophy of the sella turcica, usually without. The patient is almost invariably a child. Calcification, if present, will usually be found as a small flocculent amorphous deposit near the midline in the posterior fossa or possibly near the position occupied by the lateral ventricles. As calcification in the pineal gland of a child is uncommon, the displacement of this structure will rarely be a factor in making the diagnosis, so that without calcification we merely have the evidences of increased intracranial pressure which would not permit of making a differential diagnosis. Air studies are often of great value in the location of these tumors which, of course, can



be readily outlined if they project into one of the ventricles. Ependymomas are often confused macroscopically with the medulloblastomas. Radiotherapy offers but little in the treatment of an ependymoma, operation should be resorted to as soon as a diagnosis can be established as to its location. Then intensive radiation would be advisable in the hope of forestalling a recurrence which is unfortunately not uncommon.

Tumors of the pineal body are relatively rare, less than 2 per cent of all gliomas, and may be histologically divided into several groups which cannot be differentiated preoperatively. The tumors occur at any age but are more common in children, associated with precocious sexual development. Due to their position directly above the aqueduct of Sylvius, the patient usually succumbs within a comparatively short time as a result of the rapid increase of intracranial pressure. In spite of the frequent tendency of the pineal gland to calcify, tumors of this structure rarely contain calcium.

The roentgen diagnosis of a pineal tumor is usually very difficult, if not impossible, without air studies. The history of a precocious child with signs of increased intracranial pressure would be strongly suggestive. If calcification be present, its position and size would be strongly confirmative evidence. Air studies would in the majority of cases have to be done by ventricular puncture, and would probably show a bilateral ventricular dilatation with a probable defect in the posterior portion of a large third ventricle.

The surgical attack on a pineal tumor is extremely difficult and often impossible, so that the survival time for such a case is usually but a few months from the onset of pressure symptoms. Radiotherapy has little to offer these cases, as there is danger from intensive radiation of increasing the symptoms by producing some edema and more complete blocking of the aqueduct of Sylvius, therefore, it would be advisable to surgically drain the ventricles before instituting radiation therapy. The best that

can be offered at present in favor of radiotherapy is that it probably will slow the growth of the tumor, but so few of these tumors are available for any form of therapy that as yet our ideas regarding such possibilities are largely empirical.

A relatively rare form of tumor is the papilloma of the choroid plexus. It constitutes less than 1 per cent of all gliomas. These papillomas are rarely encountered in patients over ten years of age and their site of election is the fourth ventricle. They do not, however, entirely shun the lateral ventricles, and even the third ventricle may contain a choroidal papilloma, but this is extremely rare and may at times prove to be an extension from one of the neighboring ventricles. When such a tumor arises in the fourth ventricle it may extend through the foramen of Luschka and give rise to the signs of a lateralized cerebellar tumor. These tumors may at times become partly cystic and show degenerative tendencies. Although the choroidal papilloma is usually included in any discussion of the gliomas, it is of interest to note that it does not contain any true glial tissue.

The papilloma itself is comparatively benign, but its location is unfavorable and usually leads to a block of the cerebral fluid pathways and a consequent rise of intracranial tension. This is not always true of these growths, for one may be present without giving rise to any definite symptoms for a long time as the tumor grows very slowly. Occasionally such a tumor calcifies and so reveals its presence in the roentgenogram. If this calcification be in a large tumor, it may be possible to visualize practically the entire extent of a ventricle.

The diagnosis of a choroidal papilloma in the roentgenogram would, as a rule, be almost impossible without air studies. When such a tumor occurs in the fourth ventricle of a child it would be expected to give only the signs of a posterior fossa tumor, which are merely those of increased intracranial pressure. It rarely calcifies in a child. The history is vague unless the blockage occurs suddenly, headache as a

rule is the predominant symptom. When such a tumor occurs in an adult the diagnosis would depend upon finding a streaky or punctate deposit of calcium in the position usually occupied by one of the ventricles, with or without signs of increased intracranial pressure. One should be on guard against confusing the shadow cast by calcification in a large glomus of the choroid plexus with a papilloma, although at times such a differentiation may present difficulties. In a large percentage of benign choroidal calcifications they will be seen to be bilateral, which is against their being in a papilloma, but, of course, papillomas have been found simultaneously in both lateral ventricles. Air studies will usually permit the outlining of these tumors when they occur in an adult, but such a tumor in the fourth ventricle of a child might well defy all our pre-operative diagnostic methods to make a differential diagnosis.

Radiotherapy is to be recommended on theoretical and practical grounds. The tumors are, of course, vascular, and x-radiation has been known evidently to reduce the vascularity and hence the rate of growth. The cytoplasm of the papilloma contains mitochondria, and as these minute but evidently important cell structures are highly radiosensitive we would expect radiotherapy to have a definite degenerative influence on the cells containing them.

There are several other forms of gliomas, as can be seen from a study of the chart of Figure 1, but they are rare and one would have little hope of being able to make a pre-operative diagnosis. Their manifestations in the roentgenogram would not differ in any distinguishable manner from the more common forms which have already been discussed, and in fact to which they are, as may be seen from the chart, directly related.

In any large group of gliomas there will be a fairly sizable proportion which will have to be grouped as unclassified and mixed tumors. These complicate considerably the making of definite pre-operative and sometimes post-operative diagnoses, because they may simulate at times any of

the better defined types. For this discussion, the group of mixed tumors and those diagnosed by the finding of cystic fluid only were eliminated.

If one has had the fortitude to read this article thus far, it must have become evident that the pre-operative roentgen diagnosis of the various glioma types is wellnigh impossible, unfortunately it often is, and we have to be content with a diagnosis of "brain tumor, probably a glioma." But as time goes on and more and more of these cases are studied with the ability to correlate history, clinical findings, and roentgen findings, an accurate pre-operative differential diagnosis becomes less and less uncommon.

It may be of interest to mention briefly some statistics bearing upon the group of tumors gathered together for this discussion, in spite of the fact that statistics may often be more misleading than enlightening. In the group of astrocytomas, 16 per cent were calcified sufficiently to cast a shadow on the film, and 70 per cent gave definite roentgen evidence of the presence of intracranial pathology. The cases with glioblastoma multiforme showed that 11 per cent were calcified, whereas 50 per cent showed evidences of pathology. Seventy per cent of the astroblastomas gave evidence of pathology in the roentgenogram, and 40 per cent calcified sufficiently to make localization possible. Eighty per cent of the medulloblastomas gave roentgen evidences of intracranial disease but only 3 per cent contained calcium, this consisted of one case in which there is still some doubt as to its being a pure medulloblastoma. Eighty per cent of the oligodendrogliomas were calcified and the same percentage gave evidence of pathology. The papillomas, a small group, showed that 60 per cent were calcified, and 100 per cent showed evidences of disease. Twenty-five per cent of the ependymomas were calcified and 100 per cent showed evidences of disease. Thirty-three per cent of the group of spongioblastoma polares contained calcium, and 70 per cent showed evidences of pathology.

These percentages are high, chiefly because all the cases comprising this group had symptoms sufficiently well marked to justify operative interference, which, of course, means that in each instance the tumor had progressed well beyond the incipient stage. In practically 100 per cent of those having air studies, positive localizing findings were obtained. The only exceptions were those whose ventricles did not fill sufficiently well to permit of an adequate visualization.

The problem of the why and wherefore of tumor calcification might be briefly discussed here, it is still unsolved. A few years ago it was thought that if we could encourage intratumoral calcification we might be able to add to our ability to make accurate localizations. This problem was discussed with Dr. Walter Timme, who suggested trying large doses of calcium and vitamin D. This was tried on several cases of known tumors undergoing radiotherapy, but nothing definite occurred. Such a test is, of course, neither fair nor convincing because undoubtedly the tumor metabolism is altered by the radiation. We have seen cases increase their calcium deposit while undergoing x-radiation on a normal diet and without any evident change in the blood chemistry. A further study of this problem might be very interesting.

The problem of radiation therapy of brain tumors and the gliomas in particular is still unsolved. Deery is apparently able to show cell changes after radiation in these growths, others have been unable to convince themselves of the possibility of such changes. I am inclined to believe that x-radiation can profoundly influence the cell activity of brain tumors, and that we should by no means abandon this method of attack until we have carried out more experiments and made a greater effort to discover what radiation really is capable of accomplishing.

We know that glutathione, which is a peptide-like chemical and is found in all tissues, is reduced in amount by radiation, we also believe that this substance stimulates mitosis. Therefore, it may well be

that it is the reduction of the glutathione in the tissues that reduces tumor growth, and we know that as a rule growth is reduced in proportion to the mitotic figures present. If this be true, small repeated doses would be indicated in order to keep growth quiescent or at a minimum for a long period of time so that the tumor cells may become senile and degenerate, both due to the reduction of the concentration of glutathione and the effect on the mitochondria which seems to have something to do with cell respiration. I doubt whether a massive attack on the tumor cells is the method of choice, because probably the tumor cells are but little less resistant to such an attack than the surrounding brain tissue. Nature has a tendency to compensate for the loss of any necessary substance, so that probably in time glutathione is produced in sufficient quantities to overcome the effects of radiation. This may explain the ultimate growth of Hodgkin's lymphogranulomas after being inhibited for a time by radiotherapy, the same with the medulloblastomas. Therefore, the problem may well be to modify the radiation according to the amount of glutathione present and keep its concentration at a minimum.

If, as seems likely, radiotherapy is not only a physical problem but also a definitely chemical one, then it is likely that the chemical change will be optimal at a certain temperature. If this could be determined for the gliomas and also for brain tissue, it would be conceivably possible to maintain this temperature of optimal activity by diathermy or short wave radiations, provided the temperature was found to be not too high for the tissues to withstand, and so make our radiotherapeutic efforts much more efficient.

#### SUMMARY

An attempt has been made to discuss the gliomas from the viewpoint of the roentgenologist, and to point out how in some cases pre-operative differential diagnoses may be made in the presence of the better differentiated and more common forms of

these tumors, and also to add a brief discussion of the rationale of radiotherapy

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# A STUDY OF THE EFFECT OF SKULL ROTATION ON ROENTGENOLOGICAL MEASUREMENTS OF THE PINEAL GLAND<sup>1</sup>

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**S**PACIAL orientation of the pineal has received the attention of recent investigators with particular reference to its importance in localizing masses within the cranium. Schuller (4), in 1918, was probably the first to correlate the calcification of the pineal with the lateralization of a mass. "One can also, for example, in case of displacement of the shadow of the pineal gland to the right or left of the median line in symmetrically formed skulls, conclude the cause of its displacement to be pressure on the part of the tumor or traction on the part of a brain scar."

It was not for some time, however, that routine work was done in relating the position of the pineal to intracranial masses. Naffziger (3) appears to have been the first to carry out Schuller's suggestion in a series of brain tumors. His observations concerning pineal displacement were limited strictly to those of the anteroposterior films, attempting only the lateralization of the lesion. "The degree of the pineal shift, as we have termed it, varies considerably. A common shift is a distance of about one centimeter. We have, however, found it displaced away from the lesion for a distance of 2.5 to 3.0 centimeters." He believed that its value was limited to those cases which showed increased intracranial pressure. A midline position of the pineal under such conditions of pressure indicated an infratentorial position of the mass. This writer indicated that he contemplated at some time in the future the working out of a method of determining the position of the

pineal on the lateral film which would permit the identification of displacement in the other two planes of space. It remained, however, for Vastine and Kinney (5) to work out such a method. Briefly, this method may be described in the following manner:

The greatest anteroposterior diameter of the skull was obtained, *i.e.*, from the inner table of the frontal region at its most distant point from the pineal to a similar point at the occiput. They found that in normal cases there was a definite range for the position of the pineal along this line, and that in many of their tumor series there was displacement anteriorly or posteriorly in regard to this zone. Similarly, a vertical diameter was obtained by selecting the most distant point at the inner table of the vertex of the skull to the floor of the posterior fossa, and a normal range for the position of the pineal was determined. The range for normally located pineals for skulls of varying size is best shown by means of their graphs. While the normal cases generally fall within this zone, many of the cases of brain tumor showed displacement either above, below, in front of, or behind this normal zone.

Dyke (2), in 1930, corroborated the value of this method in dealing with a very large series (nearly 2,000 cases). He called attention to the fact that some normal cases fell outside of the normal zone as established by Vastine and Kinney, the number being less than 14 per cent. The exact error in the method is difficult to determine owing to the fact that tumor suspects and tumor cases which were unverified were included in the series.

None of these writers discuss the effect of

<sup>1</sup> This question arose in discussions with Dr. W. P. Van Wagenen, whose helpful co-operation has lent much valuable aid in making this study.

rotation of the skull upon these measurements except to indicate that rotation should be avoided. Dyke states "It is quite essential to have anteroposterior or postero-anterior films exactly straight in order to be sure of the pineal shadow. Minor degrees of rotation on the lateral film are of less importance in the measurements, but for accurate measurements the film should show the floors of both anterior fossæ superimposed and the descending ramæ of each jaw also superimposed on each other."

Davis (1), in analyzing the value of pineal orientation in the diagnosis of tumors of the brain, writes "Naturally it is all-important to have roentgenograms which are taken accurately to be able to detect a small shift in position of the calcified gland. Stereoscopic lateral roentgenograms of the skull make it possible to identify small changes in the position of the gland quite readily. Sosman uses a pelvimeter fitted with earpieces and a long pointer. The earpieces are placed in the patient's ears and the head is rotated so that the pointer is directed straight upward at the target of the tube. Naffziger employs a similar device, with the earpieces of a stethoscope to insure a proper accurate position. Often a postero-anterior roentgenogram will show the position of the calcified pineal quite clearly. We

have found the pineal shift to be a very valuable aid in the lateralization of a supratentorial lesion. Its corroborative value in frontal lobe tumors with few clinical symptoms is great. We have not been able to use it as a diagnostic aid in localizing a tumor in any particular lobe of the brain, but as a lateralizing sign its aid cannot be questioned."

In our routine work the question has frequently arisen concerning the value of the result obtained in cases in which either the anteroposterior or the lateral film showed a slight degree of rotation. In many cases of brain tumor the anteroposterior film would show the pineal on measurement to be lateral to the mid-sagittal plane of the skull as determined by the midpoint between the inner tables of the sides of the skull. Often no conclusions were drawn because of the fact that the head was somewhat rotated. Such rotation is highly undesirable and, being aware of the caution urged by the previous investigators, we were commonly tempted to discount our results if the head showed any rotation. However, in doing so we frequently wondered if slight degrees of rotation might not be permissible without destroying the evidence of a pineal which was grossly displaced. If any degree of rotation was permissible, we were interested in finding out what this extent might be without

TABLE I—EFFECT OF HEAD ROTATION ON PINEAL MEASUREMENTS

Pineal in Normal Position										
Measurements of Anteroposterior (AP) Film							Measurements of Lateral Film of Skull			
Position	Deg of Rotating	Max Trans Diam Skull	Rt Side of Calv to Pineal	L Side of Calv to Pineal	Front Marker to Pineal	Back Marker to Pineal	Type of Rotation	Deg of Rotating	Frontal Bone to Pineal	Max AP Diam of Skull
AP	0°	15 5	7 8	7 7	0	0	Rotating face downward	0°	10 3	18 0
	2°	15 5	7 8	7 7	0 3	0 3		4°	10 2	18 0
	4°	15 5	7 7	7 8	1 0	0 7		8°	10 1	17 9
	6°	15 5	7 8	7 7	1 5	1 1		12°	10 0	17 8
	8°	15 4	7 8	7 6	1 7	1 3		20°	9 7	17 4
	10°	15 4	7 6	7 8	2 5	1 6	Rotating occiput downward	4°	10 1	17 9
								8°	10 2	18 0
	15°	15 5	7 7	7 8	3 9	2 4		12°	10 1	17 9
								20°	10 2	17 9

viating results We started this investigation feeling very certain that any considerable degree of rotation would throw

of the calvarium in place (target-film distance, 30 inches)

The results of this preliminary test

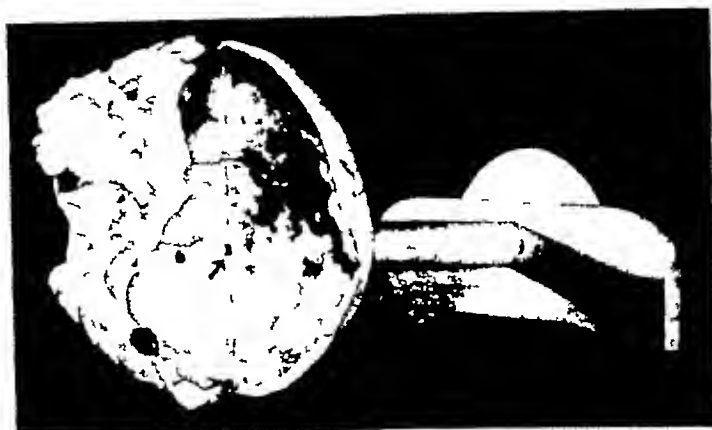


Fig 1 Radiopaque pineal oriented within cranium of dried skull showing manner of maintaining position of the skull during the exposure The round shaft which rotates within the collar of the stand and a protractor scale furnished a suitable means of changing the degree of rotation at will

our measurements vastly off, but we did wish to find out if a minor degree really invalidated the measurements

Our curiosity led us to set up a skull of normal shape (linear index 84), with a pineal of lead properly oriented according to Vastine and Kinney measurements (Fig 1) The skull was 16 cm in length with a biparietal diameter of 15.5 centimeters It was fastened to a support as shown in the illustration, with a protractor scale to indicate the degree of rotation employed Having obtained a film free of rotation, the head was then turned through increasing degrees of rotation For the first test the skull was placed in the antero-posterior position

Markers were placed at the mid-line on the forehead and the occiput to give us additional information concerning the change in relationships between the position of the pineal and these two markers These markers, which were opaque, were of different shapes to distinguish them from one another and also from the pineal gland Two, 4, 6, 8, 10, and 15 degrees of rotation were used, in each case obtaining a radiograph with the pineal and opaque markers

(Table I), which were somewhat of a surprise to us, yielded the following data Without rotation, the pineal fell at the mid-sagittal plane as would be expected The measurements from the pineal to either side of the skull (inner table) were 7.8 cm and 7.7 centimeters The total transverse width of the skull was the sum of these two, or 15.5 centimeters As will be observed these measurements are within 1 mm when the center of the pineal is employed as the measuring point With two degrees of rotation the transverse diameter remained unchanged and the measurements concerning the midposition of the pineal likewise remained unaltered The pineal did not shift to one side of the mid-line provided the midpoint along the maximum transverse diameter was taken as the criterion It should be noted, however, that, due to their location in regard to the center of rotation, the opaque markers on the front and back of the head were separated from the pineal, the anterior one falling to one side of the pineal and the posterior one to the other Using four and six degrees of rotation, the pineal still fell at the mid-point between the most distant



points of the inner table. As the rotation increased the opaque markers on the front and back portions of the head showed more separation from the pineal, the anterior one showing the greater amount due to the fact that the latter was farther from the film. At 8, 10, and 15 degrees there was relatively little difference in the transverse diameter of the skull. This did not exceed 1 mm, which represented an error possibly

due to measurement alone rather than to any actual change in the transverse diameter. At 15 degrees the experiment was stopped because the extent of the rotation was so excessive that it would exceed any amount of rotation which would ever be encountered, even under poor conditions of technic.

The observation is striking that, regardless of any ordinary amount of rotation,

TABLE II—EFFECT OF HEAD ROTATION ON PINEAL MEASUREMENTS

Pineal Displaced 1 cm. to Right of Mid line  
Anteroposterio and Postero-anterior Measurements      Measurements of Lateral Film

Position	Deg of Rotation	Max Trans Diam	Rt Side Calv to Pineal	L Side Calv to Pineal	Front Marker to Pineal	Back Marker to Pineal				
Anteroposterior rotating rt face downward	0°	15 4	6 5	8 9	1 4 R	1 2 R	Rt lateral rotating rt face downward	0°	10 4	17 9
	2°	15 4	6 5	8 9	1 4 R	1 0 R		4°	10 3	17 8
	4°	15 4	6 5	8 9	0 3 R	1 8 R		8°	10 5	17 9
	6°	15 3	6 5	8 8	0 0	2 0 R		12°	10 5	17 9
	8°	15 1	6 5	8 6	0 9 L	2 4 R		20°	10 4	17 8
	10°	15 2	6 5	8 7	1 5 L	2 7 R	Rotating rt occiput downward			
	15°	15 2	6 6	8 6	2 8 L	3 3 R		4°	10 4	17 9
Rotating left face downward								8°	10 4	17 8
	0°	15 6	6 5	9 1	1 8 R	1 1 R		12°	10 3	17 8
	4°	15 6	6 5	9 1	2 4 R	0 8 R		20°	10 0	17 8
	8°	15 5	6 4	9 1	3 3 R	0 3 R	Left lateral rotating left face downward			
	12°	15 6	6 5	9 1	4 0 R	0 0		4°	10 4	17 9
	20°	15 7	6 4	9 3	5 8 R	1 0 L		8°	10 3	17 9
								12°	10 2	17 9
Postero-anterior rotating left occiput downward	0°	15 9	6 6	9 3	1 3 R	1 3 R		20°	10 2	17 9
	4°	15 9	6 7	9 2	1 1 R	1 8 R	Rotating left occiput downward			
								4°	10 5	17 9
	8°	16 1	6 8	9 3	0 2 R	2 5 R		8°	10 7	17 8
	12°	16 1	6 8	9 3	0 5 L	3 1 R		12°	10 7	17 7
	20°	16 1	6 9	9 2	1 7 L	4 4 R				
Rotating rt. occiput downward	4°	16 2	6 7	9 5	2 1 R	0 8 R				
	8°	16 2	6 7	9 5	2 9 R	0 0				
	12°	16 2	6 7	9 5	3 4 R	0 4 L				
	20°	16 1	6 7	9 4	4 2 R	1 4 L				

neither the maximum transverse diameter of the skull nor the position of the pineal along this maximum transverse

employed, in which the pineal was displaced laterally, anteriorly, posteriorly, superiorly, and inferiorly, to determine if displace-

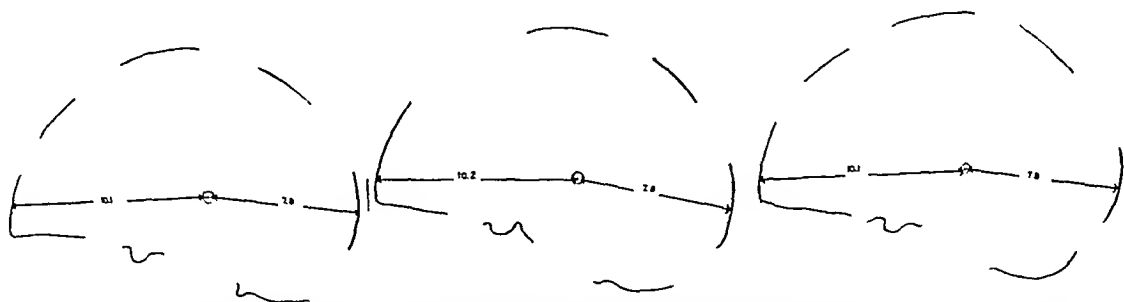


Fig 2 Tracings of lateral films of experimental skull films (1) without rotation, (2) 8° rotation, (3) 12° rotation The measurements do not change appreciably until 12° has been exceeded

diameter changes The anterior and posterior markers, as would be expected, showed increasing separation from one another and from the pineal as rotation occurs It is important to recognize the advantage of using the maximum transverse diameter of the skull in determining lateral displacement rather than any points at the brow or occiput

Experiments were also carried out employing the postero-anterior rather than the anteroposterior position to determine if reversing the position of the head would alter results This was found to have no appreciable effect Lateral films were next obtained, turning the head 4, 8, 12, and 20 degrees No change in the anteroposterior diameter of the skull exceeding 2 mm occurred until 12 degrees of rotation were employed The anteroposterior diameter of the skull and the distance from the frontal bone to the pineal likewise changed very little It will be noted that with the extent of rotation employed in these experiments, the position of the pineal is not materially altered along the maximum anteroposterior diameter of the skull (Table I) Such rotation as is apt to occur in routine work does not invalidate the results if the pineal is in normal position

It next became important to learn if a displaced pineal would be recognized in the presence of rotation Similar experimental conditions of the skull were em-

ployed in these two planes of space could still be identified Table II lists the results when the pineal was displaced 1 cm to the right of the mid-line Independent of the position employed in securing films (whether the brow or occiput was down against the film) and the direction of the rotation, the position of the pineal remained essentially unchanged, provided measurement was taken along the plane of the maximum transverse diameter The distances between the front and back markers and the pineal changed constantly with the degree of rotation It is obvious that a pineal displaced to the right of the mid-line will appear to the right of both the front and back markers of the skull in unrotated skulls If rotation occurs, the degree of separation between the marker and the pineal will vary according to the direction in which the head is turned, and as rotation increases the distance between one of the two markers and the pineal will decrease until they are superimposed and finally the pineal will be observed to be on the opposite side of this marker as the rotation becomes extreme The placing of markers at the mid-line over the forehead and over the occiput does not appear to be desirable, therefore, for the identification of pineal displacement On the other hand, one has a very easy method of determining pineal displacement by locating the mid-point of the maximum transverse diameter of the skull, and determining displacement

directly by this method. The position of a pineal interpreted in this manner, independent of any rotation which may be present, will be correctly placed, *i.e.*, a pineal which is to the right of the mid-sagittal plane of the skull will appear to the right of the midpoint of the maximum transverse diameter of the skull whether rotation is present or absent.

Similar tests were carried out, employing the lateral position of the skull. Films obtained with the pineal in normal position (Table I) show no appreciable alteration of the position of the pineal when either the face or occiput is rotated downward toward the film through 4, 8, and 12 degrees. The changes in the anteroposterior diameter of the skull are likewise unimportant, until the rotation exceeds 12 degrees (Fig 2). Even when the left lateral aspect of the skull is placed against the film, with a pineal displaced 1 cm to the right of the mid-sagittal plane (Table II), rotation of the head produces no significant changes.

The displacement thus far discussed pertains entirely to lateral displacement of the pineal from the mid-sagittal plane of the skull. Other experiments were carried out, however, orienting the pineal 1 cm anterior to its normal position, obtaining films with 4, 8, 12, and 20 degrees of rotation, alternately rotating the face and the occiput downward. The data shown in Table III indicate that it is impossible by means of rotation such as may occur in routine radiography to make a pineal which is either anterior or posterior to its normal position to appear within the normal zone or to reverse the direction of its displacement. A pineal which is anterior to its normal position will continue to appear in this position, independent of rotation of the skull. Over 12 degrees of rotation are necessary before there is any appreciable change, either in the anteroposterior diameter of the skull or in the measurements of the pineal gland.

When the pineal was displaced upward or

TABLE III —EFFECT OF HEAD ROTATION IN PINEAL MEASUREMENTS  
(LATERAL SKULL FILMS)

Pineal Displaced Forward 1 cm				Pineal Displaced Downward 1 cm			
Position	Degree of Rotation	Frontal Bone to Pineal	Maximum Antero-posterior Diameter	Position	Degree of Rotation	Vault to Pineal	Vertical Diameter of Skull
Rotating rt face downward	0°	9 4	17 7	Rotating base downward	0°	8 5	13 5
	4°	9 4	17 7		4°	8 5	13 6
	8°	9 4	17 7		8°	8 5	13 7
	12°	9 4	17 8		12°	8 5	14 0
	20°	9 3	17 5		20°	8 3	14 2
Rotating occiput downward	4°	9 4	17 7	Rotating vault downward	4°	8 6	13 7
	8°	9 4	17 5		8°	8 5	13 6
	12°	9 3	17 3		12°	8 5	13 5
	20°	9 4	16 9		20°	8 5	13 7
Pineal Displaced Backward 1 cm				Pineal Displaced Upward 1 cm			
Rotating rt face downward	0°	11 1	17 7	Rotating vault downward	0°	7 9	13 8
	4°	11 2	17 8		4°	7 9	13 8
	8°	11 2	17 9		8°	7 9	13 9
	12°	11 2	17 8		12°	7 9	13 9
	20°	10 9	17 7		20°	7 9	14 1
Rotating occiput downward	4°	11 1	17 7	Rotating base downward	4°	8 0	13 9
	8°	11 0	17 5		8°	8 1	14 1
	12°	11 0	17 6		12°	8 2	14 0
	20°	10 9	16 7		20°	8 5	14 1

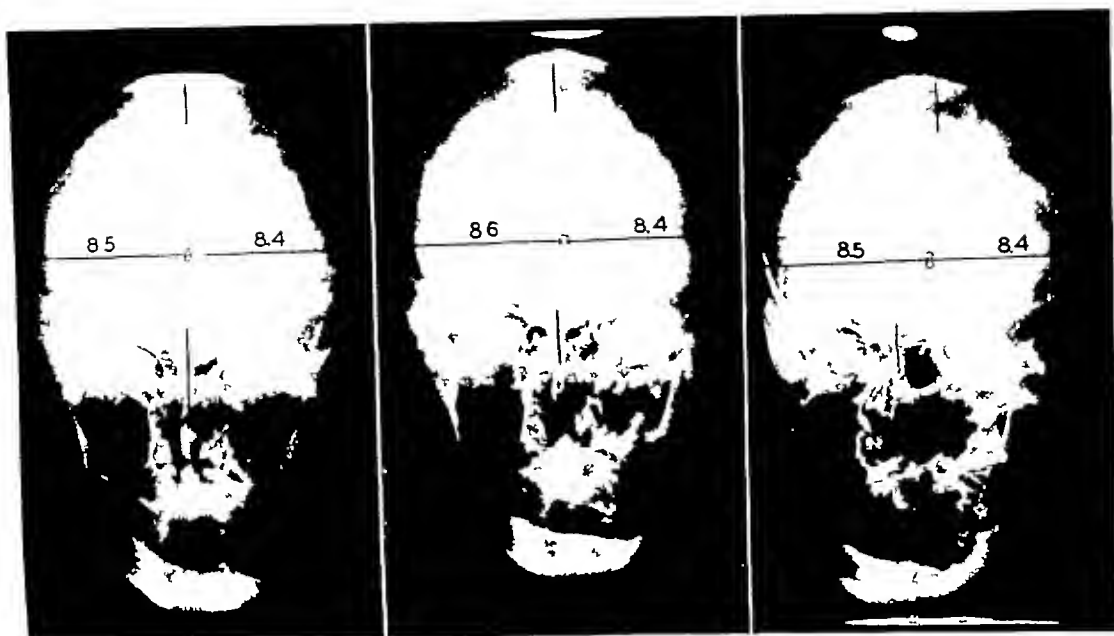


Fig 3 Anteroposterior films of normal adult male, showing effect of rotation of the head. The pineal was densely calcified and could be readily identified regardless of the degree of rotation. The radiograph at the left shows the skull without rotation, the middle one with a slight degree of rotation, and the one on the right with marked rotation. The distances from the pineal to either side of the skull do not vary more than 2 mm (normal variation), regardless of the degree of rotation.

downward along the vertical axis of the skull it was important to determine if rotation of the skull, turning the base or the vault downward toward the film, would change the measurements materially. Our tests indicate that while some slight changes occur in the vertical diameter of the skull, these changes are not of material consequence until 12 degrees of rotation are obtained. We are forced, therefore, to the conclusion that the pineal, which is displaced to one side of the mid-sagittal plane of the skull or displaced to the anterior, posterior, upward, or downward, will continue to show similar displacement of approximately the same degree of magnitude even when the direction of rotation is a favorable one to possibly alter the relationships. In general, we may say that 12 degrees of rotation and in many instances more than this are necessary before any definite change occurs and even when such changes become apparent its degree is of such slight magnitude that it would not mislead one in misinterpreting its position.

In interpreting anteroposterior or pos-

TABLE IV—PINEAL MEASUREMENTS OBTAINED FROM ROUTINE ANTEROPOSTERIOR AND POSTERO-ANTERIOR FILMS OF NORMAL SKULLS SHOWING NO ROTATION

Case	Max Trans Diam	Midpoint of Trans Diam	Inner Table to Pineal	
			R	L
1	15.9	8.0	7.9	8.0
2	17.0	8.5	8.5	8.5
3	16.8	8.4	8.5	8.3
4	16.1	8.1	8.1	8.0
5	16.7	8.4	8.3	8.4
6	18.0	9.0	9.0	9.0
7	16.7	8.4	8.5	8.2
8	17.4	8.7	8.8	8.6
9	16.4	8.2	8.1	8.3
10	16.1	8.1	8.0	8.1
11	16.6	8.3	8.3	8.3
12	16.8	8.4	8.5	8.3
13	16.2	8.1	8.1	8.1
14	16.6	8.3	8.3	8.3
15	16.5	8.3	8.2	8.3
16	16.0	8.0	8.0	8.0
17	17.4	8.7	8.8	8.6
18	17.6	8.8	8.8	8.8
19	18.0	9.0	8.9	9.1
20	17.2	8.6	8.5	8.7
21	17.6	8.8	8.8	8.8
22	17.8	8.9	9.0	8.8

directly by this method. The position of a pineal interpreted in this manner, independent of any rotation which may be present, will be correctly placed, *i.e.*, a pineal which is to the right of the mid-sagittal plane of the skull will appear to the right of the midpoint of the maximum transverse diameter of the skull whether rotation is present or absent.

Similar tests were carried out, employing the lateral position of the skull. Films obtained with the pineal in normal position (Table I) show no appreciable alteration of the position of the pineal when either the face or occiput is rotated downward toward the film through 4, 8, and 12 degrees. The changes in the anteroposterior diameter of the skull are likewise unimportant, until the rotation exceeds 12 degrees (Fig 2). Even when the left lateral aspect of the skull is placed against the film, with a pineal displaced 1 cm to the right of the mid-sagittal plane (Table II), rotation of the head produces no significant changes

The displacement thus far discussed pertains entirely to lateral displacement of the pineal from the mid-sagittal plane of the skull. Other experiments were carried out, however, orienting the pineal 1 cm anterior to its normal position, obtaining films with 4, 8, 12, and 20 degrees of rotation, alternately rotating the face and the occiput downward. The data shown in Table III indicate that it is impossible by means of rotation such as may occur in routine radiography to make a pineal which is either anterior or posterior to its normal position to appear within the normal zone or to reverse the direction of its displacement. A pineal which is anterior to its normal position will continue to appear in this position, independent of rotation of the skull. Over 12 degrees of rotation are necessary before there is any appreciable change, either in the anteroposterior diameter of the skull or in the measurements of the pineal gland.

When the pineal was displaced upward or

TABLE III—EFFECT OF HEAD ROTATION IN PINEAL MEASUREMENTS  
(LATERAL SKULL FILMS)

Pineal Displaced Forward 1 cm				Pineal Displaced Downward 1 cm			
Position	Degree of Rotation	Frontal Bone to Pineal	Maximum Anteroposterior Diameter	Position	Degree of Rotation	Vault to Pineal	Vertical Diameter of Skull
Rotating rt face downward	0°	9 4	17 7	Rotating base downward	0°	8 5	13 5
	4°	9 4	17 7		4°	8 5	13 6
	8°	9 4	17 7		8°	8 5	13 7
	12°	9 4	17 8		12°	8 5	14 0
	20°	9 3	17 5		20°	8 3	14 2
Rotating occiput downward	4°	9 4	17 7	Rotating vault downward	4°	8 6	13 7
	8°	9 4	17 5		8°	8 5	13 6
	12°	9 3	17 3		12°	8 5	13 5
	20°	9 4	16 9		20°	8 5	13 7
Pineal Displaced Backward 1 cm				Pineal Displaced Upward 1 cm			
Rotating rt face downward	0°	11 1	17 7	Rotating vault downward	0°	7 9	13 8
	4°	11 2	17 8		4°	7 9	13 8
	8°	11 2	17 9		8°	7 9	13 9
	12°	11 2	17 8		12°	7 9	13 9
	20°	10 9	17 7		20°	7 9	14 1
Rotating occiput downward	4°	11 1	17 7	Rotating base downward	4°	8 0	13 9
	8°	11 0	17 5		8°	8 1	14 1
	12°	11 0	17 6		12°	8 2	14 0
	20°	10 9	16 7		20°	8 5	14 1

the turning should not be considered significant. In reviewing some of our recent skull radiographs we set aside all those apparently normal cases showing calcified pineals on either the anteroposterior or postero-anterior films. These were divided into two groups (Tables IV and V), those in which no rotation of the head was present and, secondly, a group in which some degree of rotation was present. The amount was in most cases of a slight degree, though in six out of 20 cases the amount of rotation was considerable. In no case, however, did the degree of rotation approach that observed in the experimental dried skull. A series of 22 normal cases without any rotation showed a maximum difference of 2 mm in the measurements between the sides of the skull and the pineal. In a series of 20 skulls in which rotation was present, 2 mm likewise was the maximum difference in the measurements on the two sides. It would appear quite safe, therefore, to assume that differences of 2 mm should not be interpreted as due to pineal displacement and, secondly that, regardless of any slight degree of rotation which may be present, no allowance need be made for rotation.

The rationale underlying these relationships is best explained by means of mechanical diagrams. Figure 4 shows the effects of rotation of a brachycephalic skull on the projected pineal measurements of the film. It will be noted that in this skull at least 15 degrees of rotation are required before the projected measurements are altered. Figure 5 shows a similar result with a dolichocephalic skull. The effect of rotation is more pronounced in a skull with a long anteroposterior diameter, but, in spite of this effect, over 10 degrees of rotation are required before materially affecting results. Even at 15 degrees the proportional relationships of the pineal vary only 1 per cent from those obtained in the true lateral position.

#### CONCLUSIONS

1. A study of the effect of rotation of the head upon pineal orientation has been

made employing the anteroposterior, postero-anterior, and lateral positions of the skull.

2. A pineal located in normal position will not appear displaced on the anteroposterior or postero-anterior film even in the presence of rotation of the head such as might occur in routine radiography, provided the midpoint of the maximum transverse diameter of the skull is accepted as the criterion to determine the displacement.

3. A pineal displaced laterally will be correctly interpreted as to direction and extent of displacement in the presence of rotation if this same criterion is employed.

4. Measurements of the lateral film indicate that those showing rotation not exceeding 12 degrees may be interpreted and the position of the pineal may be determined directly by the usual measurements without making any allowance for the rotation.

5. These findings have proven to be reliable for pineals which have been displaced along either of the two planes of space relating to the lateral film, *i e*, along the anteroposterior or vertical diameters of the skull.

6. In determining lateral displacement of the pineal by means of the anteroposterior or postero-anterior films an allowance of 2 mm in making measurements on either side of the midpoint of the maximum transverse diameter of the skull has been found desirable in routine work to allow for slight mechanical errors which arise in making measurements and minor variations in skull symmetry.

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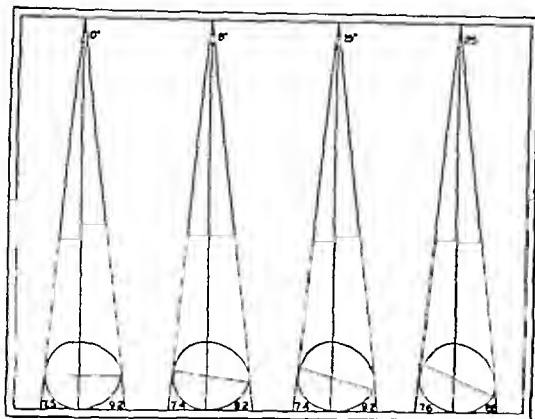


Fig 4.

Fig 4 Effect of head rotation upon pineal measurements (brachycephalic skull with linear index 0.87)  
No appreciable change in measurements is noted until the rotation is in excess of 15°

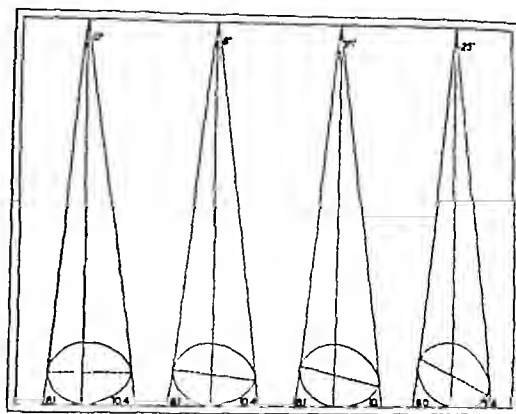


Fig 5

Fig 5 Effect of head rotation upon pineal measurements (dolichocephalic skull with linear index 0.71)  
No change is evident in the pineal measurements until 8° is exceeded. Even at 15° the percentile change is small

TABLE V—PINEAL MEASUREMENTS OBTAINED FROM ROUTINE ANTEROPOSTERIOR AND POSTERO-ANTERIOR FILMS OF NORMAL SKULLS SHOWING ROTATION

Case	Max Trans Diam	Mid point Trans Diam	Inner Table to Pineal		Extent of Rotation
			R	L	
1	16.6	8.3	8.4	8.2	Considerably turned
2	17.5	8.8	8.8	8.7	Slightly turned
3	17.0	8.5	8.5	8.5	Slightly turned
4	16.2	8.1	8.1	8.1	Slightly turned
5	17.3	8.7	8.7	8.6	Slightly turned
6	16.9	8.5	8.4	8.5	Slightly turned
7	16.4	8.2	8.2	8.2	Slightly turned
8	17.2	8.6	8.5	8.7	Considerably turned
9	16.8	8.4	8.4	8.4	Considerably turned
10	17.6	8.8	8.7	8.9	Slightly turned
11	16.2	8.1	8.2	8.0	Slightly turned
12	18.1	9.1	9.0	9.1	Slightly turned
13	17.2	8.6	8.6	8.5	Slightly turned
14	16.8	8.4	8.4	8.4	Considerably turned
15	18.2	9.1	9.2	9.0	Slightly turned
16	17.2	8.6	8.6	8.6	Slightly turned
17	16.8	8.4	8.4	8.4	Considerably turned
18	17.3	8.7	8.7	8.6	Slightly turned
19	16.7	8.4	8.5	8.2	Considerably turned
20	15.9	8.0	7.9	8.0	Slightly turned

tero-anterior films no displacement of the pineal should be considered unless the difference between the measurements obtained between the pineal and the two sides of the skull exceeds 2 millimeters. Such precautions are found not only neces-

sary in practical work but this would appear desirable from a theoretical standpoint since one cannot assume that the center point of calcification always represents the center of the pineal and furthermore it is unsafe to assume that the two sides of the cranium are strictly bilaterally symmetrical. We have found from experience that variations of 2 mm or less should be considered normal.

To illustrate the effect of rotation in actual clinical work the skull films of a patient are shown in Figure 3. This individual was selected because on examination he showed a very opaque pineal and because there was no history suggestive of any space-occupying mass within the brain. The first film was obtained without any rotation of the skull, the pineal was found to be 8.5 cm from the right side of the calvarium and 8.4 cm from the left side. The head was then intentionally turned to a slight degree and measurements of 8.6 and 8.4 cm, respectively, were obtained. The head was finally turned to an extreme degree, in fact, to an extent that would not be permitted in routine radiography of the skull. Even with a high degree of turn, the pineal oriented itself very close to the midpoint along the transverse diameter, i.e., 8.5 cm from the right side of the calvarium and 8.4 cm from the left. The 1 mm of difference obtained in the course of

metal of low vapor pressure at high temperatures so that the anode will not volatilize and deposit a coating of metal on the bowl of the x-ray tube (*tungsten, tantalum, and platinum* possess these properties, tungsten being superior)

**Transformers**—The essential parts of a high voltage transformer consists of two separate coils of wire wound around a soft iron core. One coil of a comparatively small number of turns of wire of rather large diameter is connected to the incoming voltage and is called the primary, the other coil, consisting of a large number of turns of rather fine wire, is called the secondary. In such a transformer, the voltage is transformed from low to high, and at the same time the current changes from high through the primary to small through the secondary. In a filament transformer, in which the incoming voltage is reduced, the primary coil has a greater number of turns compared to the secondary coil.

If an alternating current is sent through the primary coil and the secondary coil makes a closed circuit, a current will be generated in the secondary coil. The current in the secondary coil is an *induced current* from the current in the primary coil. Since the current in the primary coil is changing its direction 120 times a second, in a 60-cycle alternating current source, the magnetic field of force which always surrounds a wire carrying a current and perpendicular to the wire, also changes in magnitude. In an alternating current, the current rises from zero to a maximum, dropping to zero in  $\frac{1}{120}$  part of a second in the next  $\frac{1}{120}$  part of a second the current reverses its direction, again starting at zero current, rising to a maximum, and then back to zero, making a complete circuit in  $\frac{1}{60}$  of a second. Since the magnetic field of force, generated in the primary coil, changes in magnitude in the same manner as the alternating current, an alternating current of the same type is induced in the secondary coil. Therefore, a changing magnetic field of force is responsible for induced currents.

Where it is necessary to have a direct

current source, a motor generator can be used to produce an alternating current, and with an alternating current source, the voltage can be transformed. Since an induced current can be produced in the secondary coil of a transformer because of a changing magnetic field of force, anything that might interrupt a direct current connected to the primary of the transformer would also interrupt the magnetic field of force, causing a change in magnitude from a maximum to zero. If the current can be interrupted many times a second, then a workable induced current can be generated in the secondary coil. Interrupters have been and are still used to interrupt direct current sources in order to obtain a changing magnetic field.

A moving magnetic field from a magnet will induce a current in a coil of wire. This can be demonstrated by moving a magnet inside a coil of wire connected to a galvanometer. Every movement of the magnet will be indicated by a reading of the galvanometer. If the north pole of a magnet be thrust downward in the coil, the reading on the galvanometer may be to the right, and if the magnet is pulled upward out of the coil, the reading of the galvanometer will be to the left. It is seen, therefore, that any *changing magnetic field of force* about the secondary of a transformer will induce an alternating current in the secondary coil.

The voltage produced in the secondary coil compared to the voltage in the primary coil is approximately proportional to the number of turns of wire of the secondary to the number of turns of the primary coil. It is, therefore, possible to have a transformer increase the primary voltage, as happens in the high voltage transformers for producing a voltage on the target of the x-ray tube, and in a low voltage transformer for reducing the voltage to be applied to the filament of the x-ray tube.

The secondary coil of the high voltage transformer is usually grounded half-way between the terminals. Approximately half of the total voltage between the terminals of the transformer is above and half



# PROBLEMS IN RADIATION THERAPY<sup>1</sup>

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## PART I — PRODUCTION OF X-RAYS

**B**EGINNING with the terminals of the switch-box and ending with the x-ray target, an attempt will be made to give important intervening steps in the production of x-rays

*X-ray Tubes* —An x-ray tube is a glass envelope, or bulb, containing a filament and anode sealed into the glass and so placed that the filament is opposite the anode. In order to produce x-ray tubes which will withstand the bombardment of a target with fast moving electrons, all metallic parts before being sealed into the x-ray tube must be treated with heat in a vacuum furnace. The x-ray tube, containing all parts sealed into the bulb, is then placed in a furnace and the bulb sealed to a vacuum pumping system. The temperature of the furnace is increased and maintained at a point just below the temperature at which glass begins to soften. The temperature is maintained for a matter of hours in order to liberate the occluded gases of the glass walls. The terminals of the x-ray tube are connected to a high voltage energizing unit, and as the voltage is increased on the target, the gases liberated by the hot filament, the target and any occluded gases from the walls of the x-ray tube are pumped out of the bulb. This process is kept up, gradually increasing the voltage on the target, until there is no more gas liberated after prolonged operation at voltages and milliampere currents greater than the ratings of the x-ray tube.

*Cathode* —The size of the focal spot is governed by the diameter and shape of the spiral filament and also the relative position of these with respect to the target. In a fine focus tube, the filament is placed

farther back in the focussing cylinder

The focus of x-ray tubes designed for therapy have been made divergent by Coolidge in projecting a molybdenum pin through the center of the filament

The line focus with an anode face at 20 degrees instead of the conventional 45 degrees, makes possible an x-ray tube of greater capacity with the retention of the fine definition of a smaller round focus tube.

Metal disks about the filament are intended to intercept stray electrons from striking the glass.

*Choice of Anode* —Less than 1 per cent of the kinetic energy ( $\frac{1}{2} mv^2$ ) is consumed in producing x-rays by the impact of electrons at the face of the target of an x-ray tube, and more than 99 per cent of the kinetic energy goes into heat. The capacity of an x-ray tube depends upon the dissipation of heat from the target. A fine focus x-ray tube will not have as high rating as to voltage and milliamperage current as a broad focus tube. In a fine focus tube, the heat is concentrated over a smaller area of the target than in a broad focus tube. An increase of voltage will cause a greater quantity of heat to be developed in the target because the velocity of the electrons is increased. As the milliamperage current is increased, a greater number of electrons strike the target, hence more heat is developed.

The choice of anode depends upon (1) *metal of high atomic weight*, because the quality of x-rays from a target is a function of the atomic weight, (2) *metal of high melting point* so that the target may withstand the greatest amount of heat and therefore insure a higher capacity x-ray tube, (3) *metal of high thermal conductivity* so that the heat that is generated will be dissipated as quickly as possible and therefore insure a greater capacity x-ray tube, (4)

<sup>1</sup> Read before the Pennsylvania Radiological Society at Williamsport Pa., June 5 1936

nal of conductor *A*, current will pass across the junction to No 1, from No 1 to No 2 brush through a conductor, across to *X*

manner, the target intermittently carries a positive charge of electricity The disk, toroids, or cross-arms are so set on the

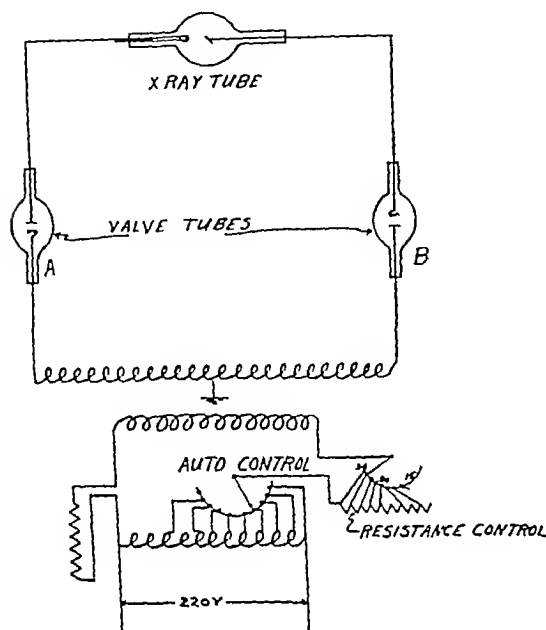


Fig 2

Fig 2 Half wave rectification

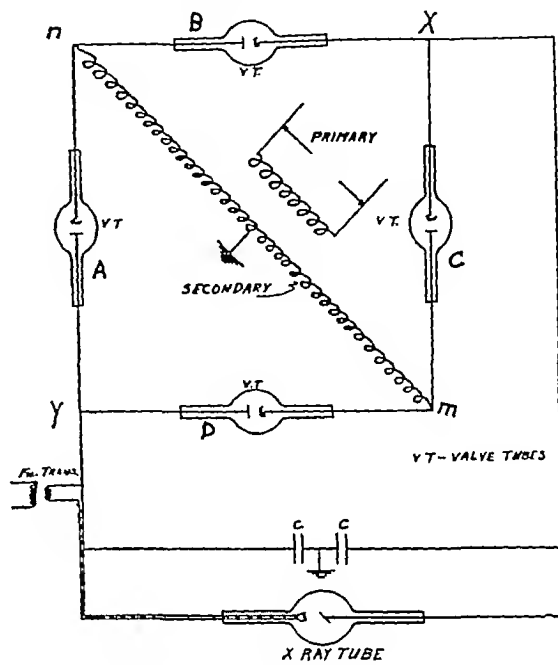


Fig 3  
FULL WAVE RECTIFICATION

Fig 3 Full wave rectification and constant potential

through to the target of the x-ray tube The attraction of the electrons from the filament to the target conducts the current across to the filament, to *Z*, across the space to No 4 brush, through the conductor to brush No 3, across to *Y* and back to the transformer by way of conductor *B* While the alternating current is changing in direction, the rectifying disk has made  $\frac{1}{4}$  of a revolution, placing brush No 1 in the position of brush No 2 in reference to terminal *X*, which is connected to the target Brushes 2, 3, and 4 have also advanced  $\frac{1}{4}$  of a revolution, as will be shown in Part 2 Due to the change in the direction, the alternating current is passing upward through transformer conductor *B*, across to brush No 2, through a conductor to brush No 1, across to *X*, to the target and filament of the x-ray tube and to the terminal *Z*, across to brush No 3, through the conductor to brush No 4, across to *W*, the terminal of the transformer In this

shaft of the synchronous motor that each peak of the alternating current half-cycle is conducted to the target

There is an interval of time during which brush No 1, passing from *W* to *X*, is not conducting current from either *W* or *X* The rectifying disk is so arranged on the shaft of the synchronous motor that during the interval when there is no current being conducted, the voltage has passed the positive peak, through zero and on the way to the negative peak Brush No 2 begins to conduct current from *Y* before the negative peak is reached This arrangement insures maximum peak voltage rectification and maximum output of radiation

*Valve Tube Rectification Half-wave* — With half-wave rectification, two valves are used and are connected into the high voltage circuit in such a manner that only a positive potential can reach the target Only the positive phase of the alternating current is used in the production of x-rays,

below ground potential. This method of construction requires less oil insulation and hence a smaller container for high voltage transformers.

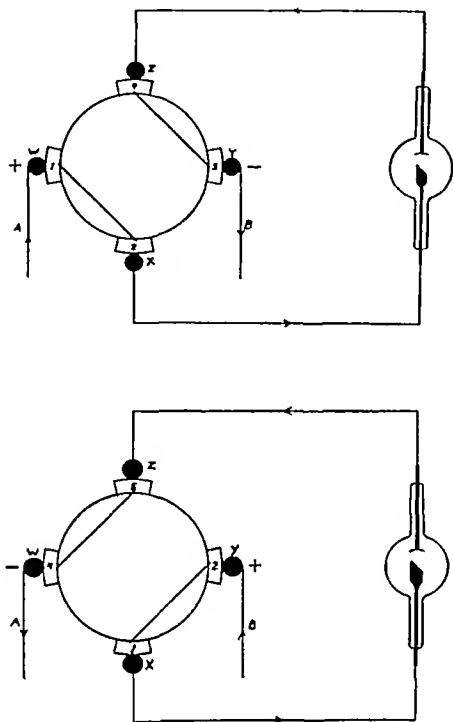


Fig 1 Part 1 (above), Part 2 (below), Mechanical Rectification

**Controls**—A control unit consists of an auto-transformer and resistance for the purpose of varying the voltage reaching the terminals of the high voltage transformer. A meter registers the voltage variation and is sometimes called a potential indicator, which enables the operator to determine how constant the primary voltage is maintained while the x-ray machine is operating. By maintaining a constant primary voltage, the operator is insured of a constant high voltage, excluding leakages due to poor insulation, etc., in the high voltage circuit.

The filament control varies the voltage applied to the primary of the filament transformer and, in turn, controls the temperature of the filament.

In mechanically rectified x-ray machines, a polarity meter indicates whether or not the positive phase of the rectified

current is applied to the target of the x-ray tube.

**Rectification**—The high voltage alternating current leaving the terminals of a high voltage transformer is connected directly to the terminals of an x-ray tube, the target becoming alternately positive and negative every  $1/120$  part of a second. This is the arrangement employed with self-rectifying units such as portable units, or high voltage units whereby two tubes are operated from the terminals of the same transformer.

The current can be rectified mechanically by rotating insulating disks, toroids, or cross-arms operating on a shaft connected to a synchronous motor which operates in synchronism with the phase changes of the alternating current. There are four collecting brushes, or shoes, on the insulated rectifiers; brushes one and two are connected together with an electrical conductor, and brushes three and four are connected together with an electrical conductor. The brushes are set in such a manner as to collect the crest of the alternating wave. The crest of the negative phase is changed in direction so that a positive potential is always applied to the target of the x-ray tube. In one revolution of a rectifying disk, four alternating wave crests are conducted to the target of the x-ray tube. Since there are 120 alternations per second of a 60-cycle alternating current, there are 7,200 alternations per minute. If the rectifying disk picks off the crest of four alternations in one revolution, the synchronous motor must make 1,800 revolutions per minute. The polarity meter indicates to the operator whether the high voltage connection to the target of the x-ray tube is conducting the positive or negative phase.

Figure 1 diagrammatically illustrates mechanical rectification of an alternating current cycle. In Part 1, A and B are conductors from the terminals of the high voltage transformer. If the direction of the alternating current is passing upward through conductor A and No. 1 brush of the rotating disk is opposite W, the termi-

nal of conductor *A*, current will pass across the junction to No 1, from No 1 to No 2 brush through a conductor, across to *X*

manner, the target intermittently carries a positive charge of electricity. The disk, toroids, or cross-arms are so set on the

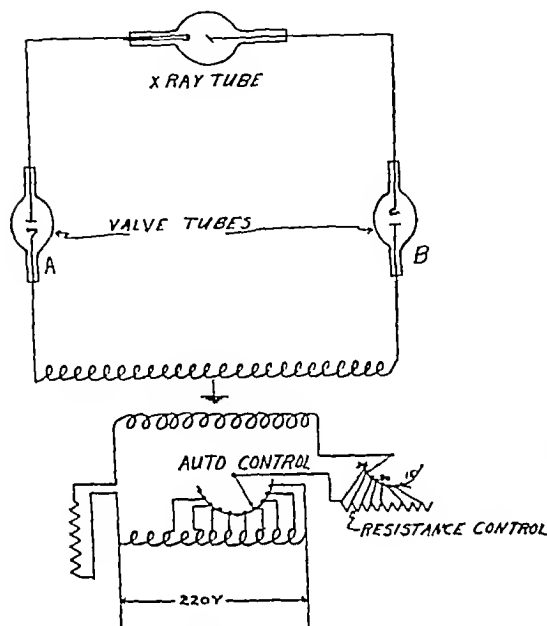


Fig 2

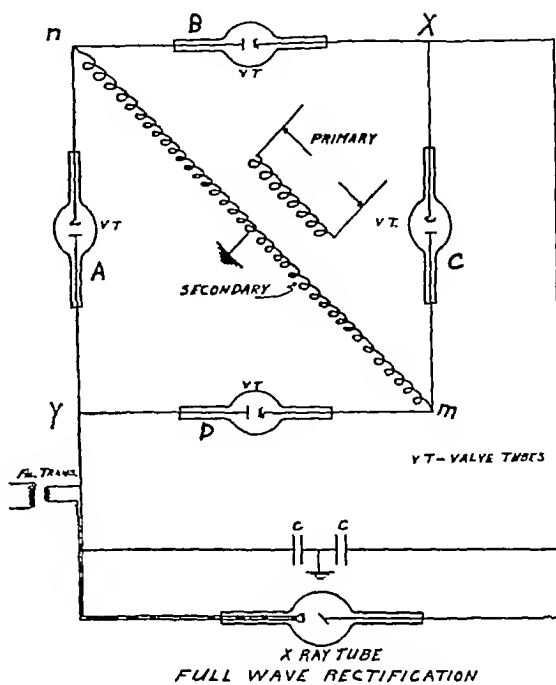


Fig 3

Fig 2 Half wave rectification  
Fig 3 Full wave rectification and constant potential

through to the target of the  $\gamma$ -ray tube. The attraction of the electrons from the filament to the target conducts the current across to the filament, to *Z*, across the space to No 4 brush, through the conductor to brush No 3, across to *Y* and back to the transformer by way of conductor *B*. While the alternating current is changing in direction, the rectifying disk has made  $1/4$  of a revolution, placing brush No 1 in the position of brush No 2 in reference to terminal *X*, which is connected to the target. Brushes 2, 3, and 4 have also advanced  $1/4$  of a revolution, as will be shown in Part 2. Due to the change in the direction the alternating current is passing upward through transformer conductor *B*, across to brush No 2, through a conductor to brush No 1, across to *X*, to the target and filament of the  $\gamma$ -ray tube and to the terminal *Z*, across to brush No 3, through the conductor to brush No 4, across to *W*, the terminal of the transformer. In this

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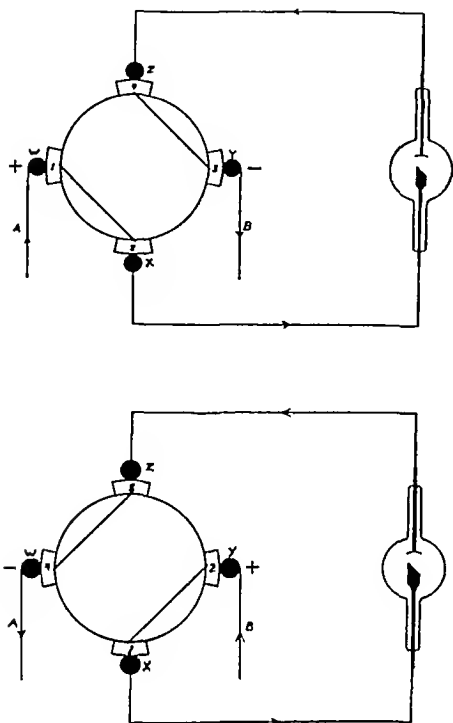


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peak voltage by the addition of condensers, which are shown as *CC* in Figure 3, and are connected across the high voltage line in parallel with the  $\gamma$ -ray tube. When the target of the  $\gamma$ -ray tube receives the maximum voltage, the condensers are also charged to the same maximum voltage. While the voltage of the alternating current cycle passes from a maximum through zero and back to a maximum, the condensers tend to maintain the maximum voltage on the target of the  $\gamma$ -ray tube. The voltage will, of course, decrease somewhat. The voltage drop in the condensers will depend upon the size of the condensers, or the quantity of electricity they can hold and the milliamperage current passing through the  $\gamma$ -ray tube. The voltage drop is called "ripple" of the condensers.

*X-rays*—The different methods of applying a voltage to the target of an  $\gamma$ -ray tube have been described. Assuming a positive potential on the target, the mechanics of the production of  $\gamma$ -rays is as follows: negative electrons are evaporated from the heated filament of the  $\gamma$ -ray tube, the number per second varying with the temperature of the wire which, in turn, varies with the current passing through the wire. An increase in the current through the filament by the filament control increases the number of electrons and, hence, increases the  $\gamma$ -ray intensity.

Since negative electrons carry a negative electrical charge, these electrons when evaporated from the filament will be attracted to the target if there is a positive charge of electricity on the target. This fact is explained by the mutual attraction of unlike electrical charges and the repulsion of like charges.

Kinetic energy is developed at the time of impact of the electron with the face of the target. The formula for kinetic energy is  $\frac{1}{2}mv^2$ , where  $m$  is the mass of the electron and  $v$  the velocity of the electron. The mass of the electron is constant, consequently the only variable in the formula for kinetic energy is the velocity. Therefore, in order to increase the kinetic energy, or the energy of impact on the face of the

target, it is necessary to increase the voltage applied to the target.

As a rule, the electron will not be arrested instantaneously at the face of the target, but will penetrate a few layers of tungsten atoms and will be arrested in its path in a more or less gradual manner. In most instances, the velocity and accompanying energy are reduced by successive stages. Considerably less than 1 per cent of the kinetic energy of an electron goes into producing  $\gamma$ -rays, while more than 99 per cent of the energy goes into heat. The electron does not necessarily continue in a straight line after striking the face of the target, but the electron may change its direction after each absorption change in its velocity. The final direction of the electron may be sufficiently changed so that it again emerges from the target. Other electrons leave the surface of the target, such as orbital electrons of the tungsten atoms expelled by the bombardment of the fast moving filament electrons under the influence of the positive charge of the target. Still other electrons, called "Compton electrons," may be liberated by the  $\gamma$ -rays produced. All of these stray electrons are called "secondary electrons" and may cause trouble in the life and construction of  $\gamma$ -ray tubes.

If all of the electrons could be instantaneously stopped at the face of the target, a large proportion of the kinetic energy of the electrons would go into the production of  $\gamma$ -rays. Since a large proportion of the electrons are stopped by a slowing-down process, a very large percentage of the kinetic energy developed at the face of the target goes into heat. Since such a large percentage of the kinetic energy develops heat and such a small percentage  $\gamma$ -rays, it becomes a serious problem for  $\gamma$ -ray tube manufacturers to devise means of dissipating the heat. Some  $\gamma$ -ray tubes have the tungsten target in the form of a button embedded in copper, because copper is a better conductor of heat. Radiating surfaces are attached to the outside of the copper stem in order to insure greater loss of heat. In high voltage  $\gamma$ -ray tubes, as

the negative phase is submerged. The milliamperage current is usually a little more than double the current observed on the milliamperage meter, due to the fact that every  $\frac{1}{120}$  part of a second there is no current passing through the x-ray tube, the milliamperage meter reading being an average.

Figure 2 illustrates half-wave rectification of high voltage alternating current by two valve tubes. If the half-cycle of the alternating current is passing through conductor toward valve *B*, the plate of valve *B* is charged positively. Electrons, generated at the filament of valve *B*, are attracted to the plate and current will pass through the valve and on to the target of the x-ray tube through the filament and on to the plate of valve *A*, to the filament of valve *A*, thereby making a complete circuit through the high voltage transformer. As the alternating current changes in direction, the current passes up to valve *A*. Since the electrons are generated by the filament and since the filament is now positive, no electrons can pass across the filament to the plate. Hence, this half-cycle of the alternating current is submerged.

*Full Wave Valve Tube Rectification* — Four valve tubes are connected in the high voltage circuit in such a manner that the target is positive during both phases of the alternating current. The voltage rises from approximately zero to peak voltage and back to zero again. The average, or effective voltage is considerably lower than the measure of the peak voltage as measured with sphere gaps.

Figure 3 illustrates full wave rectification. If the direction of the alternating current cycle is toward high voltage transformer terminal *m*, the current cannot pass through valve *D* because the filament is positively charged so no current can pass through the valve tube. The current can pass through valve tube *C* because the plate is positively charged, attracting the electrons from the filament and thereby conducting the current from the plate to the filament. At *X*, the current cannot go through valve *B* because the filament has a

positive charge. The current can, however, go in the opposite direction through the conductor to the target of the x-ray tube, to the filament and to *Y*. Here the current will not pass through valve *D* even though the plate carries a positive charge, because this would not conduct the current to the other terminal, *n*, of the transformer, thereby completing the circuit through the transformer. The current can pass through valve *A* because the plate carries a positive charge, on through the filament to *n*, making a complete circuit. The next half-cycle, *n*, is the positive terminal of the transformer. The current cannot pass through valve *A* because the filament acquires a positive charge. The current can pass through valve *B* because the plate becomes positive, the current being conducted to the filament by electrons and to *X*. The current cannot pass through valve *C* because the filament has a positive charge but can pass to the target of the x-ray tube, through the x-ray tube to *Y*. Again the current in order to reach *m* will not pass through valve *A* even though the plate is positively charged, but will go through valve *D*, because the plate takes on a positive charge, to the filament carried by electrons and to *m*, again making a complete circuit through the secondary of the high voltage transformer.

Therefore, it is seen that in a four-valve tube rectification, the target carries a positive charge all through the alternating current cycle. It is true, however, that the positive voltage will rise from zero to a peak, back to zero, repeating the same 120 times per second.

Figure 3 also illustrates a method of employing condensers in a constant potential x-ray machine. It is seen that with four-valve tube rectification, the voltage is an average from zero voltage to a maximum, or peak voltage. If the voltage is measured by a sphere gap, a reading of the peak voltage will be obtained. This, of course, is higher than the effective voltage for the reason just given.

*Constant Potential* — The effective voltage can be made to more nearly approach

peak voltage by the addition of condensers, which are shown as CC in Figure 3, and are connected across the high voltage line in parallel with the x-ray tube. When the target of the x-ray tube receives the maximum voltage, the condensers are also charged to the same maximum voltage. While the voltage of the alternating current cycle passes from a maximum through zero and back to a maximum, the condensers tend to maintain the maximum voltage on the target of the x-ray tube. The voltage will, of course, decrease somewhat. The voltage drop in the condensers will depend upon the size of the condensers, or the quantity of electricity they can hold and the milliamperage current passing through the x-ray tube. The voltage drop is called "ripple" of the condensers.

**X-rays**—The different methods of applying a voltage to the target of an x-ray tube have been described. Assuming a positive potential on the target, the mechanics of the production of x-rays is as follows: negative electrons are evaporated from the heated filament of the x-ray tube, the number per second varying with the temperature of the wire which, in turn, varies with the current passing through the wire. An increase in the current through the filament by the filament control increases the number of electrons and, hence, increases the x-ray intensity.

Since negative electrons carry a negative electrical charge, these electrons when evaporated from the filament will be attracted to the target if there is a positive charge of electricity on the target. This fact is explained by the mutual attraction of unlike electrical charges and the repulsion of like charges.

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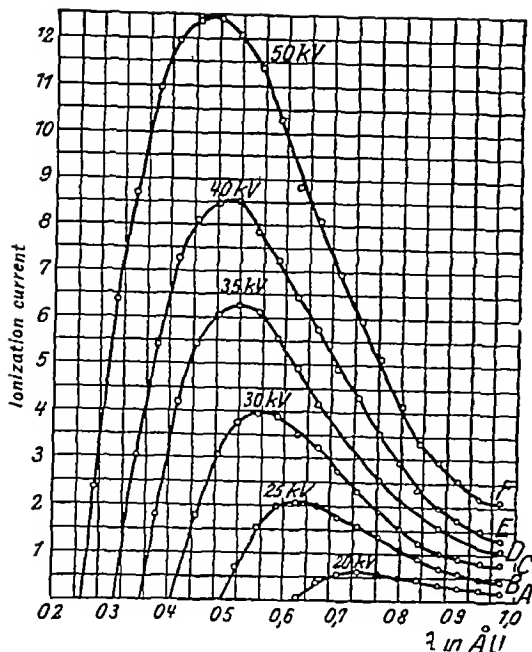


Fig 4 Intensity distribution (uncorrected) of the continuous radiation from a tungsten anti-cathode at various voltages taken by Ulrey

well as diagnostic x-ray tubes, water and oil are caused to circulate through the target and cooled in very much the same manner as automobile engines are cooled. The water may be circulated through the target by means of pumps, or it may be allowed to circulate due to gravity, the warm water, rising to the surface, causes a circulation of water.

**Kind of X-rays**—General x-rays are electromagnetic waves generated at the face of the target of the x-ray tube by the sudden stopping of the fast moving electrons. The wave lengths of these x-rays may vary from the longest wave length that can penetrate the walls of the x-ray tube to the shortest wave length that can be produced by the highest peak voltage applied to the target. This is due to the successive stages of absorption of the fast moving electrons from the filament and the variation in the velocity of the electrons due to the variation of the voltage on the target. Since at each successive impact stage the velocity of the electron is reduced, x-rays of different wave lengths corresponding to the different velocity

stages of the electron are produced, the beam of x-rays consists of a heterogeneous group of x-ray wave lengths.

An x-ray spectrum for general radiation is the same for all elements. Superimposed upon the general radiation spectrum, there is a characteristic, or fluorescent radiation with definite wave lengths, or frequencies for each element. When the electron from the filament attains sufficient velocity, which is a function of the voltage, it may enter the atomic sphere of the tungsten atom, displacing one or more orbital electrons. It requires energy to displace the orbital electron, or electrons, because the orbital electrons are held in position due to the mutual attraction of unlike charges between the nucleus and orbital electrons and the force of repulsion between orbital electrons, since like electrical charges repel. Consequently when the expelled electrons, or some other adjacent free electrons, drop back into their atomic spheres, the energy required to eject the orbital electrons is given out in the form of radiation which is characteristic of an atom of a particular element. This type of radiation is known as characteristic, or fluorescent. The voltage necessary to produce characteristic radiation is a function of the atomic weight. As the atomic weight increases, the necessary voltage to energize the atom increases. Mosley determined the x-ray spectrum for a sequence of elements and learned that characteristic radiation occurred with a definite regularity from element to element.

Wave lengths of characteristic radiation have been measured and are designated *K*, *L*, *M*, and *N*, which represent the position with respect to the nucleus, the *K* radiation arising from the energy given up by an electron nearest the nucleus and *N* radiation from electrons farther away from the nucleus.

The wave lengths of *K* radiation are shorter and are considered about 300 times more penetrating than the *L* radiation. Likewise, the *L* radiation is more penetrating than the *M* radiation.

A curve representing an x-ray spec

of radiation from a tungsten target, plotting wave lengths and corresponding wave length intensities, will show general radiation as a smooth curve. Superimposed on the general radiation curve, narrow bands of wave lengths with high intensity peaks will be seen. These intensity peaks represent characteristic radiation from the energy given up by ejected electrons from their respective electronic orbits of the tungsten atom.

Figure 4 represents measurements of radiation intensities for different wave lengths in the x-ray spectrum for general x-rays generated by voltages ranging from 20 kv to 50 kv (Ulrey). The voltages are not sufficiently high to include characteristic radiation. The area under each voltage curve represents the total radiation intensity. It will be noted that as the voltage is increased from 20 kv to 50 kv, the total intensity increases. It will also be noticed that with each increased voltage curve there is a decrease in the minimum wave length. An increase in the total intensity and a shorter minimum wave length following an increase in the voltage applied to the target is to be expected, since the speed of the electrons from the filament and the force of impact of the electrons on the face of the target are increased.

#### SUMMARY

The main features in the production of x-rays have been discussed, covering the following subjects: (1) construction of x-ray tubes, (2) high voltage and low voltage transformers, (3) control of high voltage and milliamperage current, (4) rectification of high voltage current, (5) mechanics involved in generating x-rays, (6) kinds of x-rays, (7) variation of the x-ray spectrum

with a change in voltage and milliamperage current

*(To be continued)*

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# POSTERIOR DISLOCATION OF HIP

ROENTGENOGRAPHIC STUDY IN THE ANTERIOR OBLIQUE VIEW

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IN posterior dislocation of the hip, it is essential to have roentgenographic examinations to determine the exact nature of the pathologic changes and to check the therapeutic results. Ordinarily, the examination is made in the standard anteroposterior position, with the patient lying flat on his back over the Potter-Bucky diaphragm and the film, the cen-

In order to separate the shadow of the dislocated head of the femur from that of the blade of the ilium, the writer has employed a new technic using the anterior oblique view. The patient lies obliquely on his abdomen, with the antero-lateral portion of the crest of the ilium of the affected side resting on the film. The unaffected side is elevated from the film or table at an angle of from 30 to 45 degrees

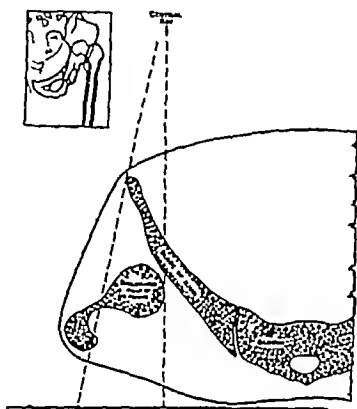


Fig 1 Illustration of the anatomical parts shown in posterior dislocation of the left hip in the standard anteroposterior technic. The inset shows the resultant view with the superimposition of the shadows of the ilium and femoral head

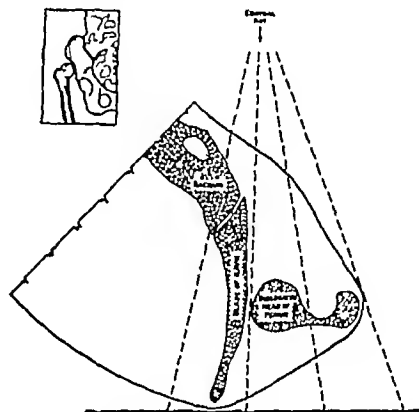


Fig 2 Illustration of the anatomical parts shown in posterior dislocation of the left hip in the anterior oblique technic. The inset shows the resultant view with separation of the shadows of the ilium and femoral head

tral x-rays are directed to the film perpendicularly through the region of the hip. This technic yields excellent exposition of the relationship of the femur and the acetabulum of a normal hip, especially in the stereoscopic view. However, in posterior dislocation the head and neck of the femur are hidden under the blade of the ilium and, consequently, the shadows of these parts are superimposed. The extent of displacement may be quite evident, but even with stereoscopic study, it is often impossible to examine the bones separately so as to visualize exactly the nature of the changes and also the relationship between the femur and the ilium.

and is supported by sand bags. The central x-rays are directed between the head of the femur and the posterior surface of the blade of the ilium. The resulting roentgenogram presents an anterior oblique view in which the bones are projected on the film separately, without superimposition. Figures 1 and 2 illustrate the technic of the two projections and the anatomical relationship of the bones in the anteroposterior and anterior oblique views.

In acute traumatic posterior dislocation, the anteroposterior view is usually sufficient for ordinary purposes. In all other types of dislocation, however, the anterior oblique view is more helpful since various

pathologic changes (*i e*, absorption or destruction of bone, proliferation of bone, formation of a false or new joint, and bony ankylosis between the femur and ilium) cannot be visualized accurately in the routine anteroposterior view. Any of these pathologic changes may influence the surgeon in making the choice of indications for treatment, *i e*, whether it is to be conservative (manipulative) or operative. The writer has used the anterior oblique technic in many cases during the past eight years, and in his experience this method has proved very useful. The following case records and illustrations show the advantages of the technic.

**Case 1** A boy, 18 years of age, was first seen on June 20, 1927, in the outpatient clinic, for deformity of the right hip joint which had developed gradually during the preceding eleven years. Physical examination revealed findings which suggested posterior dislocation of the right hip joint, probably due to a tuberculous process or to injury. Roentgenologic examination in the anteroposterior position (Fig 3) showed a high iliac dislocation of the right femur. The femoral head was poorly visualized and appeared rarefied, small, and deformed, resting against the blade of the ilium, but the degree of new joint formation could not be determined. The primary acetabulum was practically absent. The roentgenologic diagnosis was congenital dislocation of the right hip.

The patient entered the hospital for operative treatment on Sept 21, 1927, and while there he admitted having had an abscess in the right hip region, which was incised and drained 14 years previously. The abscess finally healed, but limping had been present ever since. This additional information suggested a diagnosis of suppurative arthritis with pathologic dislocation of the hip.

A "shelling operation" was performed on Sept 30, 1927. Subsequent clinical examinations showed that the patient's condition was not greatly improved. Reported x-ray examinations in the anteroposterior position showed gradual absorp-

tion of the bone grafts and no new bone formation.

In an attempt to try to find out the exact



**Fig 3** Case 1 Anteroposterior view. The femur is dislocated posteriorly and superiorly. The structures of the femoral head and neck and the posterior surface of the ilium blade cannot be clearly visualized.

**Fig 4** Case 1 Anterior oblique view. The posterior surface of the ilium is viewed in profile showing a raised articular process. The femoral head appears 'mushroomed' and the femoral neck shortened and thickened. Note that these changes cannot be visualized in Figure 3.

nature of the pathology, an anterior oblique view (Fig 4) of the hip was made one and one-half years after the operation.



Fig 5

Fig 6

Fig 7

Fig 5 Case 2 Anteroposterior view showing destruction of the acetabulum, postero-superior dislocation of the femur and also erosion of the bones of the sacro-iliac articulation

Fig 6 Case 2 Anteroposterior view taken three and one half months after that shown in Figure 5 showing less haziness and irregularity of the involved bones The exact condition of the femoral head and ilium cannot be determined

Fig 7 Case 2 Anterior oblique view taken on the same date as that shown in Figure 6 The changes of the femoral head and neck of the iliac blade are clearly demonstrated, also, bony ankylosis can be seen

(Feb 2, 1929) This roentgenogram demonstrated findings which all previous anteroposterior examinations had failed to show. The neck of the femur was very much shortened and thickened, also, the head was flattened and widened at the base (mushroomed), its articular surface being smooth and articulated, with a peculiar shallow fossa formed by a projected disc of new bone on the blade of the ilium. These findings suggested that a satisfactory articular process had been formed to accommodate the deformed head of the femur.

After reviewing this oblique view, the surgeon who operated upon the patient made the following statement on Feb 2, 1929 "The oblique view was very enlightening, showing an interesting picture of an absence of the true acetabulum and a shallow false one into which a flattened head projected. The peculiar shape of the head and neck of the femur is difficult to explain, possibly Perthes' disease could account for it, congenital dislocation is not likely. The presence of hypertrichosis and spina bifida in this case also lead one to suspect myelodysplasia as a possible diagnosis. Had I previously seen a roentgenogram taken at the angle of this one, I

would not have recommended operation. The shelf of bone which I placed in the iliac blade is too high to be effective."

*Comment*—This is the first case in which the writer used the anterior oblique view to study posterior dislocation of the hip. It was tried in an attempt to answer the request of the orthopedic surgeon who wished to determine more exactly the nature of the pathologic changes. The surgeon's note points out clearly the additional value of films taken with this technic.

Case 2 A Chinese girl, aged 19 years, came to the hospital on Jan 19, 1928, with a history of having twisted her left leg two months previously. Soon after the injury the patient became bed-ridden with an attack of high fever for a period of two weeks. This was associated with pain and swelling in the region of the left hip. Physical examination showed tilting of the pelvis with 5 cm shortening of the left lower extremity. The greater trochanter of the left femur stood out very prominently and pressure over it produced much pain. All motions of the left femur were limited and painful. A tense, tender swelling of the left hip region was present. In the region of the Poupert's ligament, there was another tender swelling, which

could be traced to join a large tender mass filling the entire left lower quadrant of the abdomen. The clinical diagnosis

articulation and the blade of the left ilium, also, the left hip joint showed posterior dislocation.



Fig 8 Case 3 Anteroposterior view, showing posterior dislocation of the femur. There is a socket like structure on the blade of the ilium superimposed over that of the femoral head. New bone formation is seen.

Fig 9 Case 3 Anterior oblique view showing a glenoid type of articular process on the blade of the ilium. There is no evidence of bony ankylosis.

was tuberculosis of the left hip joint and tuberculous abscess of the left lower quadrant.

Roentgenologic examination in the anteroposterior position (Fig 5) revealed extensive destruction of the left sacro-iliac



Fig 10 Case 4 Anteroposterior view showing posterior dislocation of the femur.

Fig 11 Case 4 Anterior oblique view showing a femoral head which is small, deformed and osteoporotic.

The patient was discharged to continue conservative treatment in another institution. Roentgenologic examination on June 30, 1928, showed some evidence of repair in the left sacro-iliac and hip joints. There was also new bone formation in the

head and neck of the femur and the blade of the ilium

Another roentgenologic examination was made on May 8, 1929, including for the first time an anterior oblique view. The anteroposterior view (Fig 6) showed less clouding and irregularity of the involved bones of the hip and sacro-iliac regions. In the anterior oblique view (Fig 7), the changes in the head and neck of the femur and the blade of the ilium were clearly demonstrated. On the posterior surface of the blade of the ilium there was a raised, well-formed disc of new bone, the surface of which was slightly concave and conformed to the shape of the deformed head and neck of the femur resting on it. A large part of the head and neck of the femur had been destroyed, and their surfaces were dense and irregular and had spicules bridging into the new disc of the ilium, indicating early bony ankylosis.

Conservative treatment was continued until November, 1929, when the patient was brought to the hospital for operative treatment. Because of the physical finding of slight motion of the left femur, an open reduction in two stages was decided upon. On Nov 18, 1929, the left hip was opened and explored. Contrary to the clinical impression, the dislocated femoral head was found to be firmly united with the blade of the ilium, as demonstrated in the roentgen films taken six months previously. In order to correct the flexion and adduction deformity of the lower extremity, the operative indication was then changed and a simple subtrochanteric osteotomy was done. The post-operative result was excellent. Recently the patient has been leading an active life as a teacher.

*Comment*—The anteroposterior view did not show the bony ankylosis which was apparent in the anterior oblique view. Comparison between the clinical and the roentgenologic findings showed that the latter allowed a more accurate diagnosis as to the nature of the ankylosis.

Case 3. A Chinese man, 42 years of age, came to the out-patient clinic with a

history of fracture of the left femur eight years previously while in Russia. He had been hospitalized and treated there for about five months, with partial recovery, but continued to have pain and weakness of the limb during walking. Physical examination showed that the greater trochanter of the left femur protruded backward and upward, and there was a bony prominence at the medial aspect of the upper end of the left thigh, which was tender upon pressure. The left lower extremity showed 5 cm shortening. Movements of the left hip were limited, especially in flexion and abduction. The clinical impression was old fracture of the upper part of the left femur.

*Roentgenologic Examination*—The anteroposterior view of the left hip region (Fig 8) showed a posterior dislocation of the hip, with new bone on the posterior surface of the ilium forming a new socket for the dislocated head of the femur. The nature of the new joint could not be determined even with stereoscopic study because of the superimposition of the parts. There was also evidence of an old fracture of the lesser trochanter.

In the anterior oblique view of the left hip region (Fig 9), the head of the femur was visualized separately from the posterior surface of the ilium. It showed a new joint of the glenoid type. There was no evidence of bony ankylosis between the femur and the ilium, in spite of the presence of fragments of bone scattered in that area.

Other roentgenograms also showed an old united fracture of the middle third of the left femur.

The patient was not treated since the function of his left hip and leg was quite satisfactory.

*Comment*—Without the anterior oblique films, the new joint could not be clearly demonstrated, and the surgeon might have explored the joint with the hope of improving the condition as in Cases 1 and 2.

Case 4. A boy, 18 years of age, was admitted to the hospital because of limping of four years' duration, which followed a

fall on the left hip. Physical examination revealed evidence of old posterior dislocation of the left hip joint.

Roentgenologic examination in the anteroposterior position (Fig 10), confirmed the clinical findings of posterior dislocation. The anterior oblique view (Fig 11) showed old deformity and slight osteoporosis of the head of the femur which was not evident in the other view. Also, the femoral head was found to be resting free

opposite the blade of the ilium. There was no formation of new bone.

Following preliminary traction, which drew the femoral head down near the acetabulum, a successful open reduction was performed.

*Comment*—In this case, the anterior oblique view demonstrated clearly the condition of the head of the femur, and served as a guide to the surgeon in his selection of the type of treatment.

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# IONIZATION OF AIR BY LENARD RAYS

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## ABSTRACT

Lenard rays in atmospheric air have been measured by means of simple ionization chambers. At ordinary intensities, encountered with Lenard rays, it is impossible to saturate such ionization chambers and this has resulted in neglect of the method for practical purposes. It has been found, however, that plotting the reciprocal current against the reciprocal voltage, a straight line results, which can be extrapolated to  $1/V = 0$ , thereby giving the current at infinite field. A number of such cases are given. Unipolar conductivity is evident in at least one ionization chamber.

area normal to the beam.<sup>2</sup> This does not involve the velocity distribution of the electrons within the beam. After investigating several, it was decided that the most direct method of measuring Lenard ray intensities was probably that employing a Faraday collector.<sup>3</sup>

On the other hand, the measurement of Lenard rays with an ionization chamber involves problems analogous to those commonly encountered in the measurement of x-rays and has the important ad-

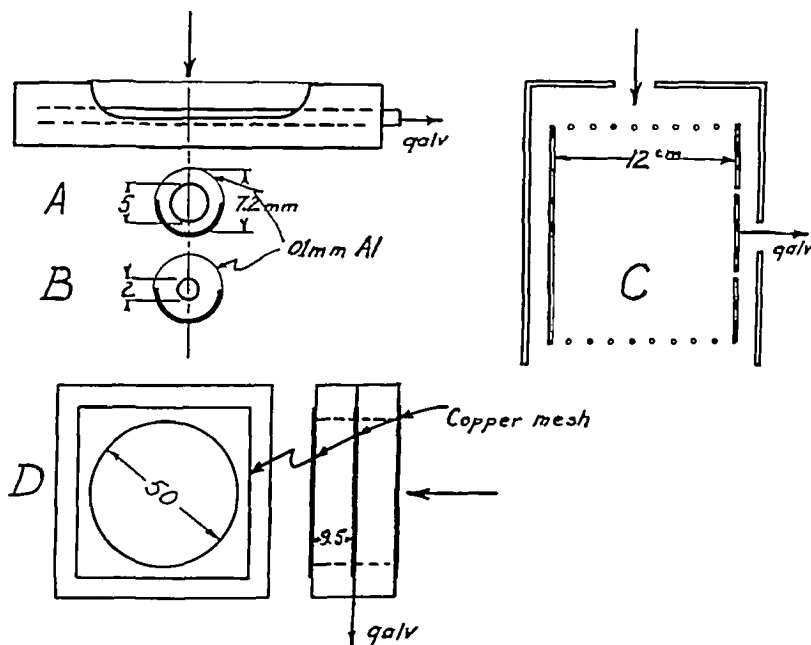


Fig 1 Ionization chambers used with Lenard rays

## I INTRODUCTION

IN 1930 a study was undertaken to arrive at a reliable method for measuring Lenard rays in such applications as the activation of ergosterol and the study of cathode ray biological effects.<sup>1</sup>

By intensity of Lenard rays is meant the rate of passage of electrons across unit

vantage of being more simply related to the absorption in biological media. The ionization current is proportional to the fractional part of the energy of the whole beam, which is absorbed in the measuring volume of the chamber. This in turn depends upon the quality or velocity distribution of the electrons—a quantity which, at best, can only be expressed in

<sup>1</sup> This work was discontinued in 1932 and since the apparatus has largely been disassembled it is not feasible at present to investigate further some of the problems suggested by a study of the old data.

<sup>2</sup> L. S. Taylor, *RADIOLOGY*, 1929, 12, 294.

<sup>3</sup> L. S. Taylor, *B. S. Jour. Research* (RP 332) 1931, 7, 57.

terms of some average distribution or composite absorption coefficient<sup>4</sup>

In addition, the air ionization method of

Zanstra<sup>8</sup> have independently arrived at similar results in the case of high pressure gaseous ionization chambers exposed to

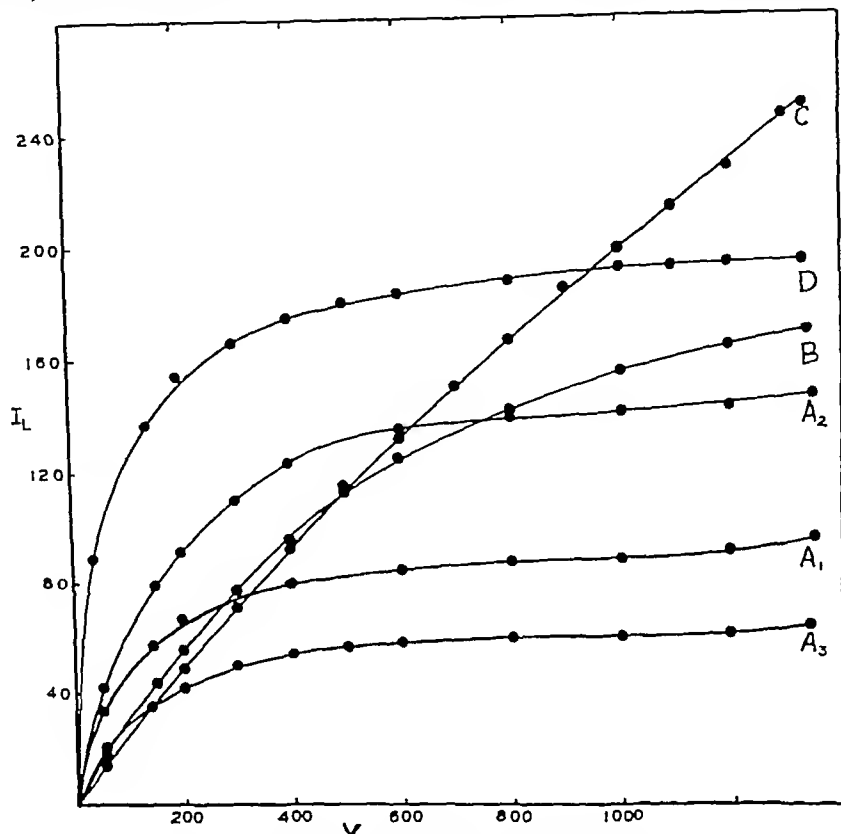


Fig 2 Current voltage curves for Lenard rays

measurement offers a convenient mode of control and is presumably proportional to the intensity of a given quality. The use of a simple ionization chamber was tried, but it was abandoned because of inability to reach saturation without causing a disruptive breakdown of the air by collision ionization under the high electrostatic fields employed.

Recent studies<sup>9</sup> have led to an application of Jaffé's theory of columnar ionization,<sup>6</sup> whereby it is possible to derive the saturation current value in liquids exposed to  $\gamma$ -rays. Clay and Van Tijn<sup>7</sup> and

gamma rays. These studies have led us to investigate the shape of the saturation curves produced by Lenard rays in air at normal pressure.

## II EXPERIMENTAL ARRANGEMENT

The detailed description of the apparatus has been given in an earlier paper.<sup>9</sup> The cathode rays were produced in a sealed-off Lenard tube with a thin glass window designed by Slack<sup>10</sup> and operated from a high voltage source of the Villard rectifier type. The voltage was approximately a sine wave above ground with a peak value of 150 kv. Input voltage was supplied by a synchronous motor generator set and

<sup>4</sup> L. S. Taylor B. S. Jour. Research (RP 666) 1934 12, 401. RADIOLOGY 1934 22, 445.

<sup>5</sup> F. I. Mohler and L. S. Taylor B. S. Jour. Research (RP 733) 1934, 13, 639.

<sup>6</sup> G. Jaffé Ann. Phys. 1913 42, 303.

<sup>7</sup> J. Clay and M. A. Van Tijn Physica 1935 2, 825.

<sup>8</sup> H. Zanstra Physica 1935 2, 817.

<sup>9</sup> L. S. Taylor B. S. Jour. Research (RP 337) 1931 7, 57.

<sup>10</sup> C. M. Slack Jour. Opt. Soc. Am. 1920, 18, 123.

hence reasonably steady. Output voltage was controlled and measured directly with a high resistance voltmeter. Tube current,

following descriptions were used. *A*, cylinder, brass tube 7.2 mm inside diameter, cut away for about half its circumference

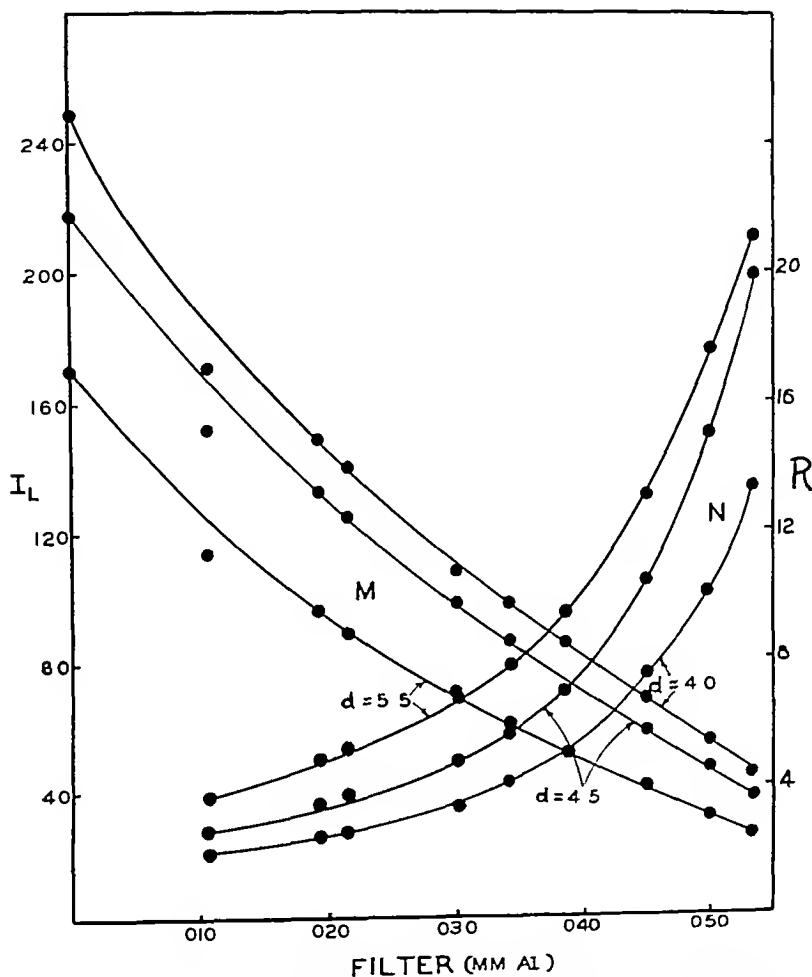


Fig. 3. Comparison of Faraday chamber measurement and ionization measurement of Lenard ray.

measured between anode and ground was maintained at  $21 \times 10^{-6}$  amp.

The ionization chamber was mounted on a track in front of the tube window. The ionization current ( $10^{-7}$  to  $10^{-8}$  amp) was measured with a galvanometer connected between the chamber and tube anode. One set of measurements for currents of about  $10^{-10}$  amp was made with a capacitance compensator and electrometer.<sup>11</sup>

Ionization chambers (Fig. 1) of the

and covered with 0.01 mm of Al, collector rod 5 mm diameter, opening length 5 cm. *B*, same as for *A*, except collector rod was 2 mm diameter. *C*, parallel plate, guarded field ionization chamber<sup>12</sup> with snout and back removed. *D*, parallel copper mesh (32), 1 cm spacing, 5 cm diameter. *E*, cylinder copper mesh (32), 8 mm inside diameter, collector 2 mm diameter. Chamber *A* was used with three different Lenard ray qualities, distinguished by *A*<sub>1</sub>, *A*<sub>2</sub>, and *A*<sub>3</sub> in the text and plots.

<sup>11</sup> L. S. Taylor, B. S. Jour. Research (RP 306) 1931, 6, 807.

<sup>12</sup> L. S. Taylor and G. Singer, B. S. Jour. Research (RP 211) 1930 5, 307.

The Lenard ray beam was limited in cross-section by a thin metal diaphragm placed in front of the tube window without at the same time introducing other variables, such as electron diffusion and change in velocity distribution. Hence,

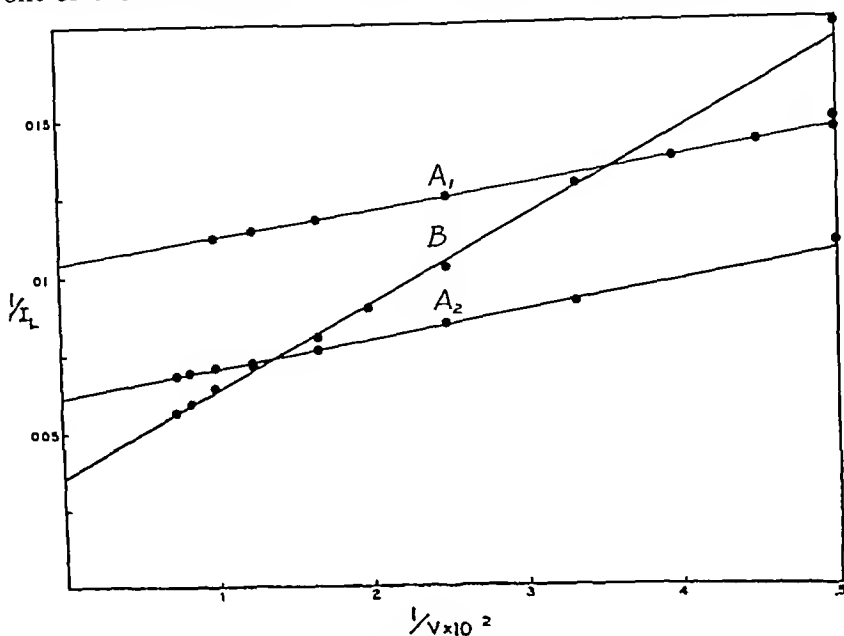


Fig. 4 Reciprocal current voltage curves

diaphragm had a diameter of 14 mm, with A, B, and E, 2.9 mm with C, and 1.9 mm with D.

### III. EXPERIMENTAL RESULTS

#### 1. Current-voltage Curves

Curves for the ionization current as a function of the applied voltage are given in Figure 2 for chambers A to D. Applied voltage rather than field strength is used as abscissas since the latter is indeterminate. It is seen in the case of curves A<sub>1</sub>, A<sub>2</sub>, and A<sub>3</sub> that noticeable collision ionization begins at about 1,000 volts, which corresponds roughly to a field strength of about 9 kv/cm. In all other cases, this high field strength was not approached and no evidence of collision ionization was noted.

It is also to be noted that at high field strengths, saturation is nearly reached, whereas for the very low fields used in parallel-plate chamber C there is no apparent evidence of approach to saturation.

It was not possible to vary the degree of the ionization by a known amount

there is no simple direct way to ascertain whether or not the ionization current below saturation is proportional to the radiation intensity. This was attempted by indirect means. Previous studies have indicated the reliability of a Faraday collector for measuring the Lenard current.<sup>9</sup> The intensity of the beam was therefore varied by filtering with thin aluminum foil, and absorption curves of the resultant radiation obtained first with the Faraday chamber and then with ionization chamber A at 900 volts, which is probably within 10 per cent of saturation. This was done for three different distances,  $d$ , between the tube window and Faraday collector or ionization chamber.

Figure 3 shows the results, where curves M are for the ionization chamber and curves N are for the ratio  $R$  of the ionization current to the Faraday current. On the assumption that the measurements by the Faraday chamber are correct, the relative sensitivity of the ionization chamber changes rapidly, increasing as the ionization becomes weaker.

An explanation for the apparently great disparity between the measurements by the two methods probably lies in the fact

plotted with the reciprocal current against the reciprocal voltage in Figures 4 and 5. It is seen that even down to comparatively

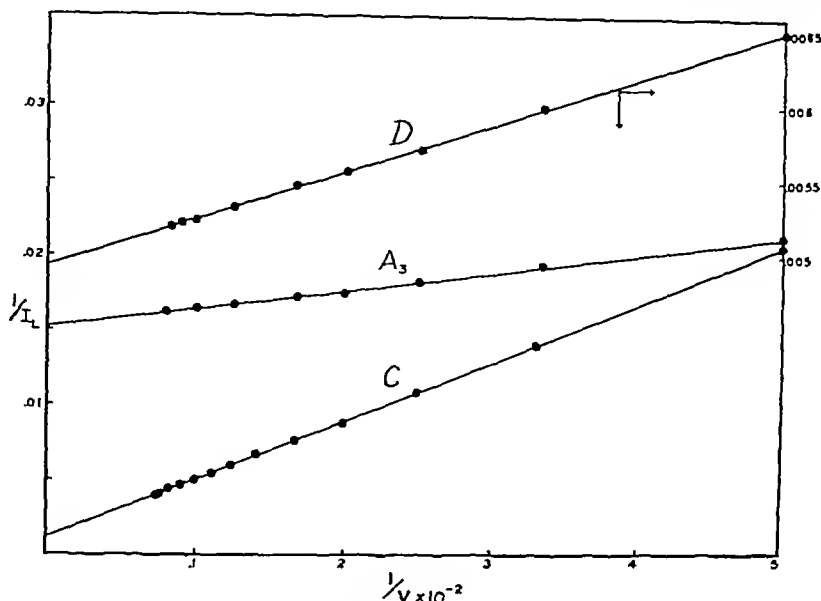


Fig 5 Reciprocal current-voltage curves

that whereas the Faraday collector measures the total Lenard current, the ionization current gives only a measure of the fraction of the energy of the electrons absorbed within the ionization chamber. With no filter, fast cathode rays with low ionizing power pass completely through the chamber. With increase in filtration an increasing fraction of the electrons terminate their paths within the chamber, and thereby produce a greater amount of ionization in accordance with Bragg's findings in terminal ionization.

## 2 Reciprocal Current-voltage Curves

Suggested by the results of plotting the reciprocal current against reciprocal voltage in the case of liquids (Mohler and Taylor) and high pressure gases (Zanstra), the above data were similarly treated on purely empirical grounds.<sup>13</sup> Such a plot compresses the scale at the upper voltages so that an extrapolation to infinite fields is rendered practical.

The data of Figure 2 were accordingly

plotted with the reciprocal current against the reciprocal voltage in Figures 4 and 5. It is seen that even down to comparatively

low field strengths there is a linear relationship between the two quantities. In the case of chamber A, the field strength of 90 kv/cm gave very nearly the saturation current, as shown in Figure 2. It would appear safe, therefore, to extrapolate the curve to  $1/V = 0$ , thereby deriving a magnitude for the ionization current  $I_\infty$  at infinite field.

Similarly the other curves are extrapolated to  $1/V = 0$ , since they are straight lines even in the extreme case of chamber C where the maximum field strength was about 0.15 kv/cm. Table 1 gives a summary of the experimental factors and also the ratio  $I_e/I_\infty$  of the highest measured current  $I_e$  to the derived maximum  $I_\infty$ .

With the exception of chambers C and D, the field strengths given do not have great significance—especially those marked with an asterisk—since in all cases, the field is radial and hence not uniform. In chambers A<sub>1</sub>, A<sub>2</sub>, and A<sub>3</sub> the radii of the inner and outer cylinders are 2.5 and 3.6 mm, respectively, so the field is considerably more uniform than in chambers B and E.

<sup>13</sup> L. S. Taylor, Phys. Rev., 1935, 48, 970

The effect of reversing the potential on the chamber is shown in Figure 6 for the cylindrical chamber E. From the simple lack of sufficient definition of the beam<sup>1</sup> and ionized volume. The effective volumes of chambers A<sub>2</sub> and B are roughly in the ratio

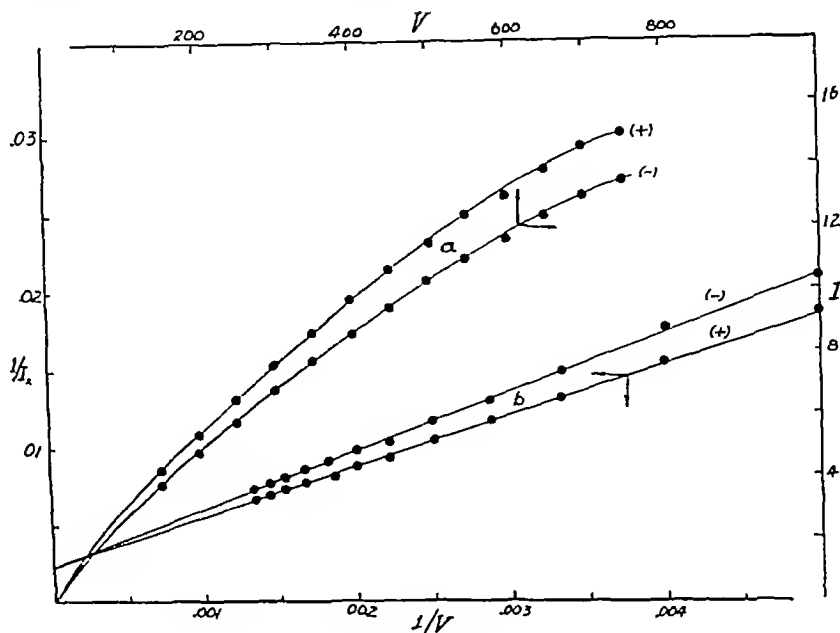


Fig 6 Reciprocal current voltage curves

current voltage curves, *a*, it is seen that with a negative potential on the collecting electrode, the ionization current is substantially larger than when it is positive. Curves *b* show the same data plotted reciprocally, it is seen that although the points fall on two distinct straight lines, they extrapolate to the same value of  $1/I_r$  for  $1/V = 0$ .

of 1/2, with which the respective values of  $I_\infty$  agree.

#### IV DISCUSSION

An attempt was made to explain the form of these ionization curves on the basis of some existing theory, but this is rendered too complicated by the inhomogeneous electric field in all chambers but C and D. The relationship between ionization current and field strength for a uniformly ionized chamber has been found by others to agree fairly well with the theories of Thomson,<sup>14</sup> Nice, and Seemann for x-rays and  $\beta$ -rays of moderate intensity (up to 5 roentgens per minute, for x-rays). However, the intensities involved here are of the order of 1,000 times as large, and hence initial and intercolumnar recombination may be of greater importance here than in the cases of low ionization densities.

Thomson's equation for the ionization

TABLE I—LENARD RAY INTENSITIES

Chamber	Tube distance, cm	Tube diameter, cm	Filter (mm)	Maximum field strength, kv/cm	$I_\infty$ Amp. $\times 10^{-4}$	$I_r/I_\infty$
A <sub>1</sub>	7.3	14		9.1	17.1	0.91
A	4.6	14		9.1	53.8	.86
A <sub>2</sub>	4.6	14	0.2 Al	9.1	21.6	.93
B	4.6	14		*3.2	91.2	.51
C		2.9		13	29.3	.28
D	6.6	9		1.4	6.65	.90
I <sub>1</sub>	4.6	14		*2.5	77.8	.35
I	4.6	14		*2.5	77.8	.35

\* Airpath between tube window and ionization chamber

Included in Table I are the values of  $I_\infty$ , which may be used for rough calculations of the ionization per unit volume, absolute values of which cannot be obtained for

<sup>14</sup> See J. J. Thomson, *Conduction of Electricity Through Gases*, Cambridge 1928.

current  $I_x$  at a given field strength  $X$ , where  $I_x$  is small compared with  $I_\infty$ , is

$$\frac{I_x^2}{I_\infty I_x} = \frac{(k_1 + k_2)^2 X^2}{\alpha/e l}$$

where  $l$  is the plate separation,  $\alpha$  the recombination coefficient, and  $e$  the charge on the electron. Taking the square root of both sides of this equation it is seen (curve C, Fig. 2) that for small values of  $I_x$  there is nearly linear relation between  $I_x$  and  $X$ . The conditions in the equation may be approximately fulfilled by the chamber C and possibly E where the ratios  $I_x/I_\infty$  were 0.28 and 0.35, respectively. It is, indeed, true that the curves are linear for these chambers, but it is equally true that they are linear for the other chambers where  $I_x/I_\infty$  is 0.9, a magnitude too large for fulfilling the conditions of approximations. Assuming that this relation holds for the maximum ionization current measured with parallel-mesh chamber D, it was found that the calculated current-voltage curve deviated by several per cent from the experimental curve even at the 98 per cent saturation point. That this might have been expected from the experimental results is obvious from the fact that for all conditions studied it was found that  $1/I_x$  was proportional to  $1/V$ .

Likewise, Jaffé's theory of columnar ionization cannot hold under conditions here used, since it is based on the assumption that the columns do not overlap and that intercolumnar recombination is, therefore, negligible. On the other hand, Zanstra has evaluated the ionization current-voltage relationship for air over a wide range of pressure, and although the deviation from the curves for uniform ionization is marked at the high pressures, there is a barely perceptible effect at the lower pressures (8.8 atmosphere). We have no explanation as to why the present data appear to follow Jaffé's laws for columnar ionization.

Unipolar conductivity such as shown

with chamber E has been explained on the basis of a marked asymmetry in the distribution of ionization in an ionization chamber<sup>15</sup>. Cases studied have usually been those in which the radiation beam passed near one plate, but it has also been pointed out that where the radiation strikes a plate, a somewhat similar condition would be set up by the relatively intense secondary radiation from the plate.

This condition probably obtains in the chambers employed in the present work. In addition, since the Lenard rays are absorbed strongly by air, the ionization density will be substantially less at the emergent side than at the entrance side of the chamber. Of particular interest, however, is the fact that regardless of the sign of the potential on the plates, the relationship of  $1/I_x$  to  $1/X$  is linear at high field strengths. Moreover, under the same radiation conditions both curves extrapolate to identically the same value of  $1/I_x$  for  $1/X = 0$ . This latter fact would seem to definitely indicate the validity of a reciprocal current-voltage relationship and the permissibility of obtaining the true saturation current by extrapolation. For it is reasonable to expect the actual number of ions formed to be independent of any potential applied to the plates (except above the field strength where collision ionization occurs) and hence yield the same saturation current under conditions where no ions are lost by recombination.

The difference in ionization current at the lower fields might also be caused by electric field inhomogeneity, but it is interesting to note that exactly similar curves have been reported by Clay and Van Tijn<sup>16</sup> for a parallel-plate chamber with air under high pressure and using gamma rays as the ionizing agent. We have also found similar results for parallel-plate air ionization chambers with very intense  $\gamma$ -rays.<sup>17</sup>

<sup>15</sup> E. Rutherford, Phil. Mag. [VI] 1901, 2, 210.

<sup>16</sup> F. L. Mohler and L. S. Taylor, B. S. Jour. Research (RP 733) 1934, 13, 659.

<sup>17</sup> Data to be published later.

# THE EFFECT ON ROENTGEN RAYS AND HYDROGEN PEROXIDE ON TISSUE LIPASE

By HELEN QUINCY WOODARD, PH D, Memorial Hospital, New York City

SINCE the chemical changes produced by roentgen and gamma rays in tissue are not well understood, it is of interest to study the effect of these types of radiation on tissue enzymes. Lipase is a suitable enzyme for such study, since Falk and his co-workers (1-7) have shown that the lipases of various tissues differ markedly in their relative actions on different esters, and that the lipase from certain malignant tumors shows similarities to that from embryonal tissue. Accordingly, we have studied the effect of roentgen rays on the lipolytic activity of extracts of Mouse Sarcoma 180 and of various normal animal tissues. We have also studied the effect of radiation on Mouse Sarcoma 180 *in vivo*.

## METHOD

The method of Falk, Noyes, and Sugiura (1) was followed with some modifications. Since many of the lipase preparations employed in the present work were quite dilute, and consequently had only slight buffering action, the esters were neutralized prior to incubation with such dilute preparations. The effect of the experimental procedures on the pH of the lipase preparations was watched, and when pH change occurred the preparations were brought back to pH 7.0 before incubation. Two of the esters used as substrates by Falk and his co-workers were omitted in the present study. Glyceryl triacetate was not used because it failed to give a clear titration end point with dilute lipase preparations. Ethyl benzoate was omitted because the previous workers reported that the behavior of various lipases toward ethyl and methyl benzoates was so nearly the same that it seemed unnecessary to study both.

Tissue extracts were irradiated in crystallizing dishes, the depth of the solution being from 2 to 3 cm. The radiation factors were 200 kv, filter = 2.2 mm Al + 1.0

mm celluloid, distance, target to bottom of dish = 43 cm, intensity = 135 r/min, dose = 10,000 roentgens. Tumors were irradiated *in vivo* through a hole slightly larger than the cross-section of the tumor in a lead shield 4 mm thick. The factors were 200 kv, filter = 0.8 mm Cu + 4.0 mm celluloid, target-skin distance = 50 cm, intensity = 44 r/min, dose = 1,000 to 1,750 roentgens.

## RESULTS

The chemical effect of roentgen radiation on non-living material is usually small (8 and 9). Preliminary work showed that this is also true of lipase preparations. It

TABLE I—EFFECT OF ROENTGEN IRRADIATION ON THE LIPOLYTIC ACTIVITY OF TISSUE EXTRACTS OF DIFFERENT CONCENTRATIONS

Each figure represents one experiment

Extract	Conc at Irradiation	Conc at Incubation	Av Change of Absolute Activity
Rabbit liver A	50 mg/c	50 mg/c	+ 3%
	50	25	- 2%
	50	10	- 3%
	50	3	- 2%
	50	1.2	- 3%
	50	0.4	- 2%
	1.2	1.2	-23%
Rabbit liver B	10 mg/c	10 mg/c	-10%
	2.5	2.5	-12%
	1.0	1.0	-19%
Rabbit liver C	2.5 mg/c	2.5 mg/c	-11%
	1.0	1.0	-25%
Whole rat A	50 mg/c	25 mg/c	+ 2%
	50	10	+ 2%
	25	25	- 2%
	5	5	+ 3%
	2.5	2.5	-13%
	1.0	1.0	-10%
Whole rat B	50 mg/c	50 mg/c	+ 1%
	25	25	- 5%
	5	5	-10%
	2.5	2.5	-15%
Rabbit kidney	5 mg/c	5 mg/c	- 7%
	1.0	1.0	-14%
Rabbit lung	5 mg/c	5 mg/c	- 8%
	1.0	1.0	-32%



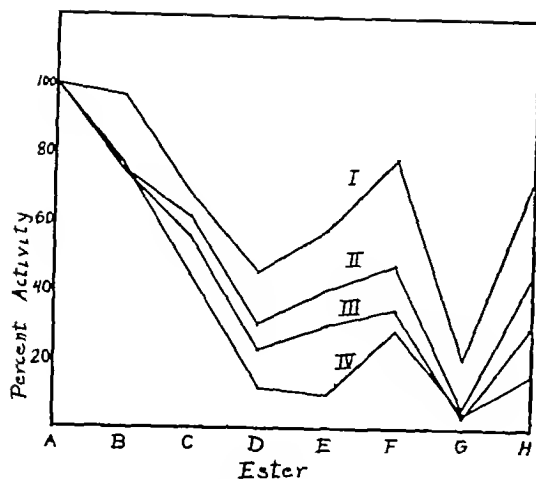


Fig 1

Fig 1 The effect of concentration on the lipase "picture" of rabbit liver extract <sup>1</sup>

Curve I = 50 mg/c c

II = 10 "

III = 1.2 "

IV = 0.4 "

Each curve represents one experiment

<sup>1</sup> Ester A = phenyl acetate  
 B = methyl butyrate  
 C = benzyl acetate  
 D = ethyl acetate  
 E = methyl acetate  
 F = ethyl butyrate  
 G = methyl benzoate  
 H = isobutyl acetate

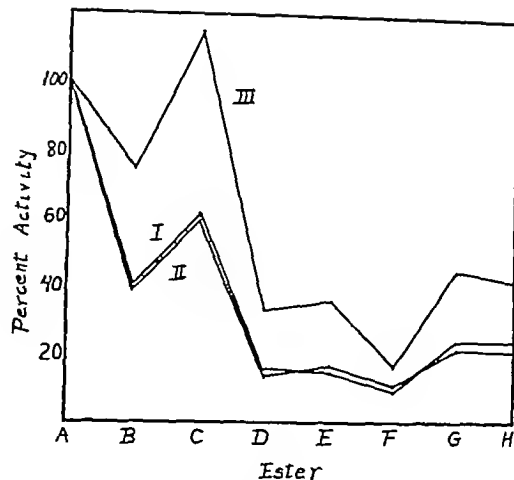


Fig 2

Fig 2 The effect of 10 000 roentgens and of 0.010 M  $H_2O_2$  on the lipase "picture" of Mouse Sarcoma 180 extract at 2.5 mg/c c concentration

Curve I = irradiated extract av. of 3 experiments

II = control extract av. of 6 experiments

III = extract in 0.010 M  $H_2O$  av. of 3 experiments

seemed probable that, if concentrated solutions, in which only a portion of the enzyme was active, were irradiated and a small part of the enzyme were destroyed, then some of the previously inactive portion might become active and conceal the effect of the irradiation. In order to detect small amounts of inactivation, the determinations of lipolytic activity should, therefore, be made on extracts so dilute that the activity per milligram of original substance is nearly independent of concentration. Accordingly, a study was made of the effect of concentration on the activity of various lipase preparations. It was found that, for the most dilute extracts with which it was possible to work, the activity of the enzyme with respect to most of the esters was nearly independent of concentration, but this was usually not

true of the activity with respect to phenyl acetate. With some preparations, this resulted in a marked change in "picture," as is shown in Figure 1 for an extract of rabbit liver. Another rabbit liver extract showed much smaller changes. Small changes in "picture" were also obtained with extracts of rat liver, rabbit kidney, rabbit lung, and whole rat. No significant changes of "picture" with concentration were found for extracts of rabbit muscle and Mouse Sarcoma 180. Whenever a change in "picture" was observed, the picture approached the embryonal type the greater the dilution of the extract. No attempt was made to determine the cause of this change in "picture," but it is possible that it is due to a change in the state of dispersion of the proteins associated with the enzyme. This is in harmony with the

observations of Falk (10) on the effect of added proteins

#### EFFECT OF IRRADIATION *in vitro*

Extracts of rat and rabbit liver, rat spleen, rat muscle, rat kidney, rat lung, and whole adult rat were irradiated at 50 mg / cc concentration and subsequently diluted. No definite radiosensitivity was observed. When, however, extracts were irradiated in dilute solution, the irradiated extracts were definitely inactivated, and the more dilute the extract at the time of irradiation (Table I), the greater the inactivation. In most cases the activity of the enzyme with respect to all the esters was diminished by about the same percentage, hence, only the average change is reported in the table. The figures for the activity toward methyl benzoate are not included in the averages, since the absolute activity of most lipase preparations toward this ester is so small that percentage changes are misleading.

In general, the enzyme "picture" was not changed by irradiation, as is illustrated in Figures 2 and 3. In a few experiments, changes in "picture" were observed, but were too small to be significant. The reduction in activity brought about by irradiation did not exceed 50 per cent in any experiment. This is not large enough to cause a change of "picture" in itself, since it was necessary to dilute extracts to  $1/5$  or  $1/10$  of the initial concentration before a change in "picture" became apparent, as is shown in Figure 1.

The absence of effect of irradiation on concentrated solutions is real, and is not due to the masking of small changes by the activation of previously inactive fractions which was discussed above. This may be seen by reference to Table I. Thus, Rabbit Liver Extract A and Whole Rat Extract A, when irradiated at a concentration of 50 mg / cc and then diluted to 1 mg / cc, showed negligible radiosensitivities. The same extracts, when irradiated at a concentration of 1 mg / cc, showed a diminution of activity due to irradiation of 23 per cent and 10 per cent, respectively.

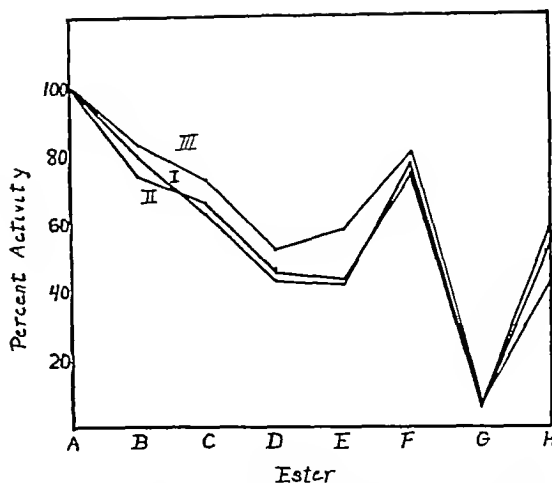


Fig 3 The effect of 10 000 roentgens and of 0 010 M  $H_2O_2$  on the lipase "picture" of rat liver extract at 1 0 mg / cc concentration  
Curve I = irradiated extract, av. of 2 experiments  
" II = control extract, av. of 5 experiments  
" III = extract in 0 010 M  $H_2O_2$ , av. of 3 experiments

#### EFFECT OF HYDROGEN PEROXIDE

Since the enzyme is inactivated when irradiated in dilute solution, but shows no significant change in activity when irradiated in concentrated solution and subsequently diluted, it seems likely that the roentgen rays do not destroy the enzyme directly, but, rather, that some intermediate product is formed which inactivates the enzyme. This would explain the greater effect in dilute solution, since the ratio of the concentration of the intermediate product to that of the enzyme would be greater the more dilute the enzyme.

An attempt was made to demonstrate the production of this intermediate product. Distilled water brought to pH 7.0 with NaOH, and saturated solutions of toluene in water at pH 7.0, were irradiated with doses of 10,000 r. Concentrated lipase preparations were then diluted with irradiated, and control portions of these solutions and their lipolytic activities compared. In six out of ten experiments the lipase was slightly but definitely inactivated by the irradiated solution, in the other experiments the effect of irradiation was within the experimental error. The effect was not due to the action of roentgen

rays on toluene, since the results were the same whether it was or was not present

It is well known that hydrogen peroxide is produced in low concentrations when water is irradiated. It, therefore, seemed likely that this was the substance the production of which in dilute enzyme solutions was responsible for their radiosensitivity. As hydrogen peroxide is also decomposed by roentgen rays, the equilibrium concentration is low. Experiments indicated that, under the conditions of the present work, the equilibrium concentration of hydrogen peroxide lay between 0.001 M and 0.0001 M. Such very dilute hydrogen peroxide solutions would not be expected to produce marked inactivation of lipase preparations added to them subsequent to irradiation, as was shown above. On the other hand, the total amount of hydrogen peroxide produced in a solution during the course of irradiation may well be large enough to inactivate appreciable amounts of enzyme, provided the enzyme is present in the solution during the course of the irradiation, and can take up the hydrogen peroxide before the latter is decomposed by further exposure to roentgen rays.

In order to test the effect of hydrogen peroxide, dilute lipase solutions were made up in solutions of "superoxol" of various concentrations, and their lipolytic activity compared with that of similar solutions made up in water. Hydrogen peroxide in concentrations below 0.010 M was found

to have little effect, as was to be expected from the work on irradiated water reported above. The results with 0.010 M hydrogen peroxide are summarized in Table II. The activity of the enzyme toward phenyl acetate was usually diminished by a larger percentage than that toward the other esters, and hence is tabulated separately. Figures for the effect of irradiation on the same lipase preparations as those used for the hydrogen peroxide work are given for comparison. There is no parallelism between the magnitudes of the reductions in lipolytic activity effected by the two agents. Thus, roentgen rays reduced the activity toward phenyl acetate of extract of Mouse Sarcoma 180 by only 11 per cent, and hydrogen peroxide reduced it by 52 per cent, while the corresponding figures for rat liver extract were 42 per cent and 14 per cent. Other differences will be observed in the table. The marked change in "picture" away from the embryonal type, sometimes resulting from the differential action of hydrogen peroxide on the activity of lipase preparations toward phenyl acetate, is illustrated in Figure 2, and is contrasted with the much smaller change in Figure 3. The figures also show the absence of effect of roentgen rays on lipase "picture" even when, as in Figure 3, the percentage reduction of activity is large. Thus, while both roentgen rays and hydrogen peroxide inactivate lipase preparations, the two effects show such

TABLE II — COMPARISON OF THE EFFECT ON THE LIPOLYTIC ACTIVITY OF TISSUE EXTRACTS OF 0.010 M  $H_2O_2$  AND OF ROENTGEN IRRADIATION IN 10,000 r DOSES

Extract	Conc Extract	Effect of $H_2O_2$		Effect of 10,000 r		No Det ns
		On Esters Other than PhOAc	On PhOAc	On Esters Other than PhOAc	On PhOAc	
Rabbit liver A	10 mg / c c	- 3%	± 0%	- 9%	- 3%	1
	2.5	- 9%	- 9%	- 14%	- 6%	1
	1.0	- 2%	- 8%	- 20%	- 14%	1
Rabbit liver B	2.5 mg / c c	- 9%	- 11%	- 11%	- 12%	2
Rabbit muscle A	10 mg / c c	- 4%	- 46%	- 12%	- 18%	2
Rabbit muscle B	10 mg / c c	- 7%	- 32%	- 23%	- 30%	2
Whole rat	50 mg / c c	- 1%	- 17%	+ 2%	- 2%	1
	2.5	- 29%	- 48%	- 15%	- 16%	2
	1.0 mg / c c	- 4%	- 14%	- 44%	- 42%	2
Rat liver	2.5 mg / c c	- 6%	- 52%	- 12%	- 11%	3
Mouse Sarcoma 180						

marked dissimilarities as to render it improbable that the production of hydrogen peroxide in irradiated solutions is responsible for all their radiosensitivity

#### EFFECT OF IRRADIATION *in vivo*

The effect of roentgen irradiation of Mouse Sarcoma 180 *in vivo* also was studied. The tumors were irradiated when about two weeks old with doses of from 1,000 to 1,750 roentgens. All parts of the animal except the tumor were shielded with 4 mm of lead. A dose of 1,500 r regularly produced a definite inhibition in the growth of the tumor, but did not cause retrogression in a period of one week. One week after irradiation the tumors were removed, the necrotic portions were discarded, and the healthy portions were extracted in the usual way. In one series the animals were inoculated with two tumors. One of these was irradiated, and the unirradiated tumor from the opposite side of the same animal was used as control. In the other series the controls were normal tumors from different animals inoculated at the same time as the ones used for irradiation. A total of nine experimental tumors and fifteen controls was used. When the four groups, tumors irradiated and inhibited, tumors irradiated and not inhibited, control tumors from animals bearing irradiated tumors, and control tumors from animals not bearing irradiated tumors, were compared, no significant difference was found in the lipase 'pictures'.

#### SUMMARY

The effect of roentgen rays and of hydrogen peroxide on the Falk lipase "pictures" of extracts of Mouse Sarcoma 180 and of various normal tissues has been studied.

When the lipolytic activities of portions of the same extract were compared over a wide range of concentration, the "picture" in some cases tended to approach the embryonal type the greater the dilution.

Roentgen rays in doses of 10,000 roentgens brought about a partial inactivation of the lipase in dilute extracts with little or no change in "picture." This appeared to be due to the formation by the roentgen rays of some intermediate inactivating substance in the solution rather than to a direct effect on the enzyme.

Hydrogen peroxide in 0.01 M concentration inactivated the lipase preparations with respect to phenyl acetate, but had much less effect on the activity toward other esters. This differential effect resulted in a change in the enzyme "picture" away from the embryonal type.

Irradiation of Mouse Sarcoma 180 *in vivo* did not result in any significant change in lipase "picture."

The author wishes to thank Dr. G. Failla, of the Physics Department, Memorial Hospital, for suggesting this problem, and Dr. K. Sugiura, of the Chemistry Department, Memorial Hospital, for supplies of tumor material and assistance in the work.

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# AN IMPROVED METHOD FOR THE TREATMENT OF CANCER STATISTICS

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From The Cancer Institute, University of Minnesota Hospital

IN presenting cancer statistics it has become customary to state results as the percentage of so-called five-year cures. The hope that a patient who has lived five years without recurrence will be in no further danger of one is partly justified by the observation that about 95 per cent of recurrences make their appearance within a

sentation in a very unsatisfactory state, and in view of the active research in this field improvement is imperative.

At first glance, correlation analysis would seem the solution to this problem, it would seem an easy and sure method of predicting length of life from such data as type of neoplasm, method of treatment, age, length

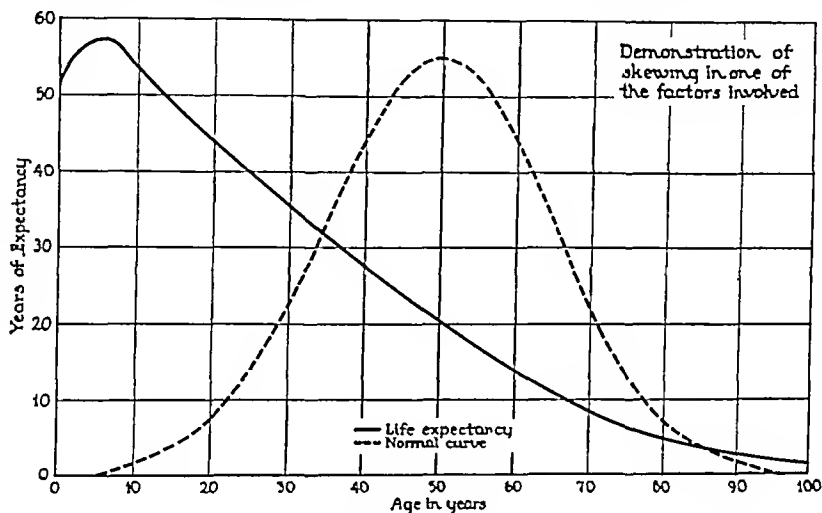


Fig 1 Demonstrating "skewing" or deviation from a symmetrical distribution

five-year period, however, this measure does disregard an appreciable proportion of the late recurrences. Moreover, the five-year-cure rate fails to account for the patients who die of causes other than cancer, and without evidence of recurrence. The common practice of listing such patients separately amounts to no more than transferring the statistical burden from the author to the reader, without helping in any way to solve the problem. Then, too, many authors publish data in terms of cure rates for other periods than five years. At present the only method of comparison between such data is reference to the original articles, and these often do not give sufficient details to permit comparison. These difficulties leave the problem of pre-

of disease, etc., and the correlation coefficients would give comparison between the various methods of treatment in otherwise comparable groups. But closer inspection shows that the applicability is only superficial. The chief difficulty is the fact that practically all biologic data have "skewed" distributions, true normal or symmetrical distributions being the exception. Figure 1 shows an example of this: the solid line, which represents life expectancy at various ages, differs markedly from the superimposed normal curve. This "skewing" is prominent in most factors in cancer statistics; for instance, the age incidence of neoplasms is markedly asymmetrical, while such factors as form of treatment can be dealt with only by considering them point

distributions of a discontinuous function Since ordinary correlation analysis is based

gence introduces important discrepancies, especially when comparisons are involved

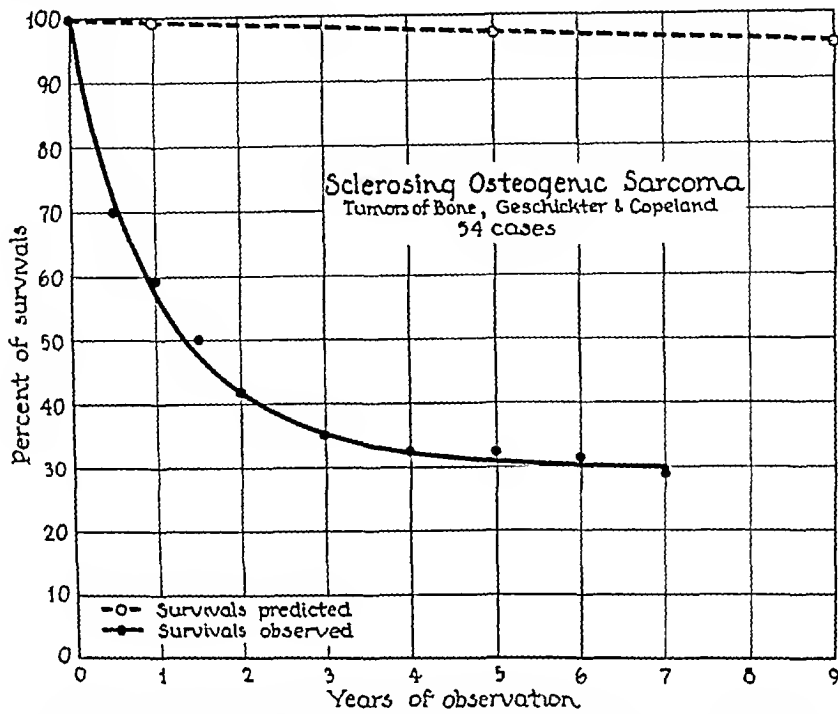


Fig 2 Note that normal survival is almost 100 per cent in this group, while the actual survival observed only flattens out after about five years

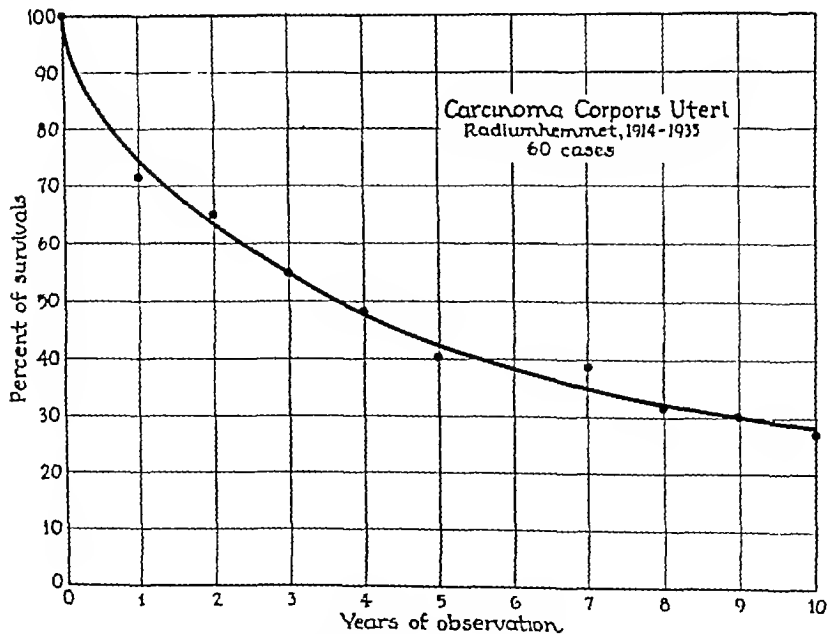


Fig 3 Note that the curve never appreciably flattens, showing how misleading it is to speak of five-year cures in this condition

on the assumption that the distributions. Never on 11 with 1

general methods for approximating irregular correlation surfaces, as the number of cases is ordinarily too small

fulfilled, which is seldom the case in cancer statistics. Thus, a large state clinic is apt to receive those moderately developed

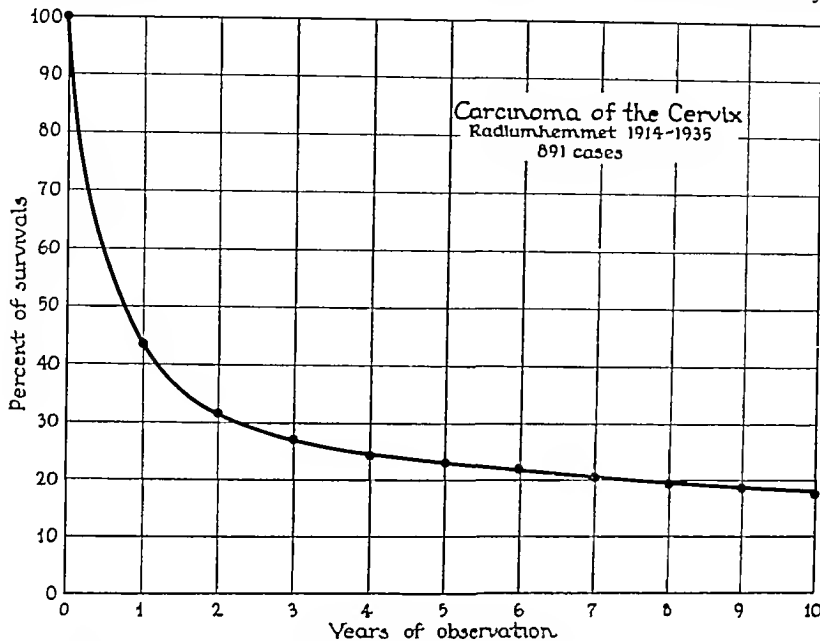


Fig 4 The curve shows only a partial flattening falling between those shown in Figures 2 and 3

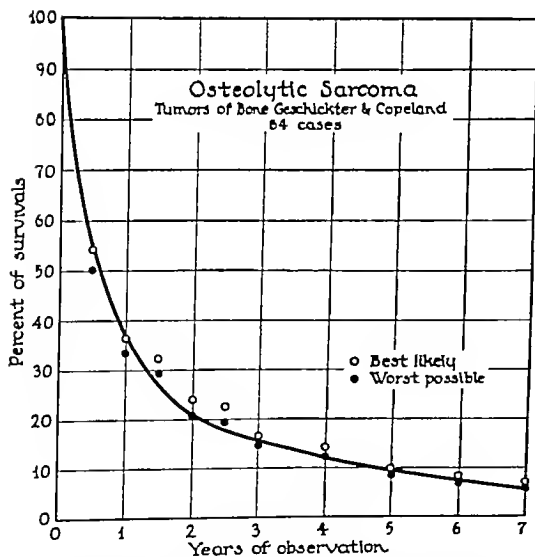


Fig 5 Again the curve does not flatten out. Note that the partial follow up hardly influences the location of the points whichever assumption they be calculated upon. This is about 90 per cent follow up for the seven years

Then, too, ordinary correlation analysis assumes in calculating reliability that the conditions of simple sampling have been

cases which lend themselves to ready diagnosis outside, while those not so well developed or far advanced are less apt to be sent in, for obvious reasons. Moreover, there are definite changes with the passage of time in the incidence and distribution of cancer. Such selection invalidates the ordinary measures of statistical reliability, and the interpretation of results is correspondingly difficult.

In an attempt to solve some of these problems, the following method is presented for consideration. Let us set up a survival curve as a measure of results, stating the percentage of patients living year by year from first observation (Figs 2, 3, and 4). Such a curve gives a succinct statement of results for as many years as there are data. Nor is it absolutely necessary that all patients be followed the same length of time, since each point may represent the percentage of patients followed that long, provided that the number at that point is large enough to assure reasonable accuracy, say, from 25 to 30 cases.

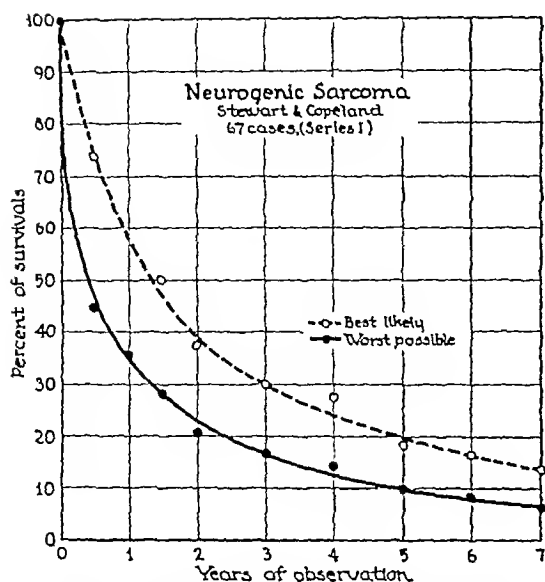


Fig 6 This represents only 60 per cent follow up (cases gathered from the literature) and demonstrates the use of two curves between which must lie the true survival curve

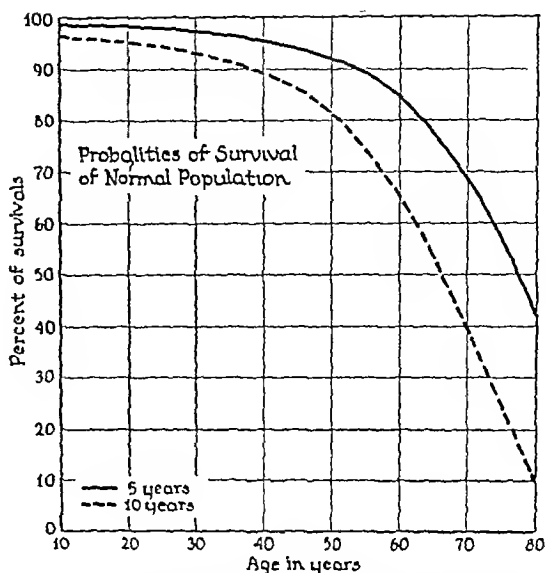


Fig 7 Showing probability of survival for five years and ten years at various ages the average of which for the cases in the series gives the dotted curve in Figure 2

Comparison of such curves may then be made point by point, over as much or as little of the curve as is given, while a general comparison of the whole may be had by comparing the area encompassed under like time intervals of the two curves. With survival curves it makes less difference how long the series has been followed, except insofar as longer observation makes for greater accuracy, although three years is probably an absolute minimum, since shorter periods have not yet been proven sufficient for evaluation.

As an additional basis for comparison, the use of the mode commends itself. This measure, which is the period at which 50 per cent survival occurs, has several definite advantages. It is a single number, which renders comparison easy. It is easily calculated, and requires a comparatively short follow-up. It commends itself to those not statistically minded as a sort of average, and is consequently easy to comprehend. Its chief statistical disadvantage, its inability to fit into further mathematical treatment, is of little importance in this work, particularly as the accompanying survival curve should give

any statistician enough material to calculate such other measures as he desires.

The question of lost cases is always one of great difficulty. Theoretically, it invalidates a series to have any lost cases, nor is there any possible method of making a valid correction. The fact that such cases, far from being a simple sample of the data, are a badly biased group, makes the use of the usual statistical measures of reliability quite inaccurate, and this fact clinches the necessity of adequate follow-up in all cancer research. In practice, since we seldom attain this degree of perfection, it is probably not too great an error to assume that the lost cases are a simple sample of the group, behaving in the same fashion as those followed if—and only if—the percentage lost is small, perhaps less than 10 per cent. If the percentage is over this, it is advantageous to present two survival curves, one based on the assumption mentioned and another on the assumption that all lost patients died shortly after their last visit (Figs 5 and 6). Since these two curves would represent the best likely and the worst possible results, one might say with some confidence that



the true curve did, in fact, lie somewhere between them. To take a concrete example, suppose that of 100 cases we suc-

ceeded in following 90 for a period of three years. Let us further suppose that of the 90 followed, 20 are living and 70 dead. On the first assumption, the three-year ordinate would be 20/90, or 22.2 per cent, while on the second it is 20/100, or 20 per cent, a difference of 2.2 per cent, which is particularly insignificant when one considers that the standard deviation of the percentage is about 4 per cent. The best possible result, if all the lost cases were living, is probably of little importance, but even that is not significantly different in this example, being only 7.8 per cent higher.

It is difficult to allow properly for patients dying of causes other than cancer. For comparison, probably the simplest way is to construct an artificial survival curve based on the average probability of survival for the group for two or three points covering the range of the data (since the curve is quite smooth, not more than three points will be needed). In most series this curve will drop little from the

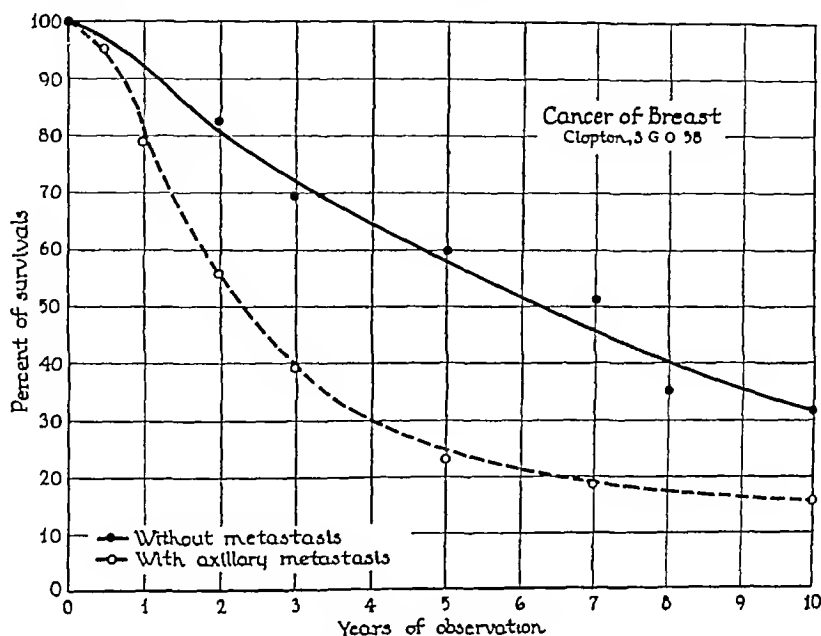


Fig 8 Showing a very marked case of failure to flatten out. The irregularity of the curve throws some question on its validity.

would show a significant fall (Fig 2). Figure 7 shows graphically the probability of survival for five and ten years at various ages, based on the "British Offices Mortality."

Of course, all the difficulties are not entirely removed, and a certain amount of extra work is involved. The initial portion of the survival curve tends to be over-emphasized by the casual reader because of its larger bulk. The reliability of each point is lessened by the age variations of patients in the group. Comparisons between curves are only valid if the same general type of neoplasm is represented. Statistical measure of the accuracy of the points determined is lacking, or at least rather unreliable, because of the peculiar distributions involved. Deaths not due to cancer are only discounted in a large series.

But even in the face of these difficulties, this measure of results provides a fuller and more accurate statement than any current method, this is even plainer when one

notices that every death is considered at approximately the time it occurs, which must afford a truer picture than consideration of the number surviving any arbitrary limit. The survival curve with the adjuncts suggested is so manifestly superior to the five-year cure rate that its use should be universally adopted.

#### SUMMARY

It is proposed to use survival curves and modal survival as a measure of results in treating cancer, in place of the five-year

cure rate. Certain adjuncts are suggested, the advantages pointed out, and the difficulties briefly discussed.

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## AIR IN THE HEPATIC DUCTS AN X-RAY SIGN OF BILIARY FISTULA<sup>1</sup>

By ROBERT A. POWERS, M D, *Palo Alto, California*

**S**PONTANEOUS biliary fistulae are probably not as rare as is generally supposed. Before the advent of the roentgen ray, clinical diagnosis of this condition was rarely made. Moller (1), quoted by G. A. Moore, states that out of 22 cases of gallstone ileus which he operated upon, the correct diagnosis was made in three cases. Courvoisier (2) states that about 4 per cent of his cases of intestinal

come into general use, diagnoses of biliary fistulae have been more frequent. In 1933, Firor (5) collected 40 odd cases from the roentgen literature. As the writer has seen four cases in one small hospital, there appears to be no question but that many times this number have been unreported. Firor credits Busic with having made the first roentgen diagnosis in 1919. In 1920, Carman (6) reported a case in which a



Fig 1 A

Fig 1-A Case 1. Acute gall bladder fistula—pneumocholedochus—gallstone ileus. Note branched tubular air shadows in hepatic ducts also dilated jejunum. The calculus as seen in Figure 1 C was opaque but not visible on this film. An ileostomy was performed with complete recovery.

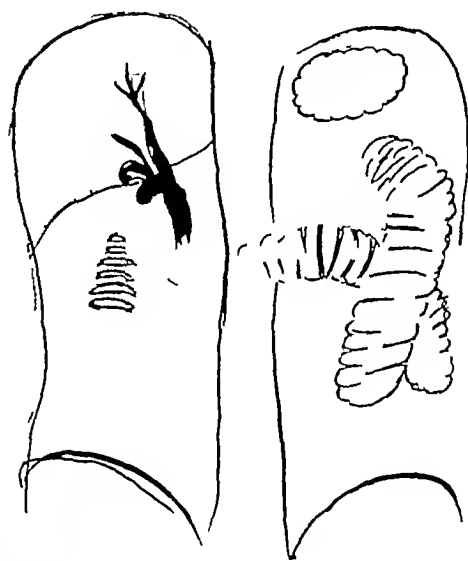


Fig 1 B

Fig 1-B Case 1. Diagrammatic representation of the foregoing (cf Fig 1-A).

obstruction from all causes were due to gallstones. Powers (3) found four cases, or 2.2 per cent, in 179 operations for intestinal obstruction. Kehr (4) found 100 fistulae, or about 5 per cent, in 2,000 gall-bladder operations.

Since roentgen-ray examinations have

pyloric carcinoma had ulcerated into the gall bladder, barium found its way into the hepatic ducts. In 1925, Havlicek (7) reported a case and stated that the condition had not been previously described. In 1933, Lucas Henry (8) reported a beautifully illustrated case in which the bile ducts were outlined first by air and then by barium.

Biliary fistulae are usually due to the

<sup>1</sup> Read before the Radiology Section of the California Medical Association at the sixty-fourth Annual Session, Yosemite National Park, May 13-16, 1935.

erosion or ulceration of large gallstones, but may result from benign or malignant ulcerations and may originate in either the gastro-intestinal or biliary tracts, duodeno-biliary fistulæ are by far the most common. In the 40-odd cases collected by Firor, 36 were duodeno-biliary fistulæ, four biliary colic fistulæ, two hepato-bronchial fistulæ, and one gastro-biliary fistula. Von Schlapfer (9) states that in one case a stone was expelled in the vomitus and a gastro-biliary fistula was subsequently found. Fistulæ have also been reported between the gall bladder and kidney and the gall bladder and the urinary



Fig 1 C Case 1 The gallstone producing the rupture and intestinal obstruction was not visible on the original film. Its failure to cast a shadow was not due to insufficient calcium as demonstrated on this film taken following its removal. It must have been below the area filmed.



Fig 2 A

Fig 2 A Case 2 Pneumocholedochus, tubular air shadow in hepatic duct. This shadow should rarely be confused and practically always indicates an anastomosis between the biliary tract and some portion of the intestinal tract, usually the duodenum.



Fig 2 B

Fig 2 B Case 2 Pneumocholedochus. The barium is seen entering an elongated viscus superior to the duodenal bulb. This was thought to be the gall bladder containing a solitary negative calculus. At operation it proved to be a greatly dilated common bile duct containing a stone. A large diverticulum is seen in the second portion of the duodenum.



Fig 2-C

Fig 2 C Case 2 Pneumocholedochus (24 hours). The common bile duct still retained barium while the upper gastro intestinal tract was empty.

bladder (10). One case is said to have voided 200 stones in the urine.

Roentgen findings in biliary fistula may be air or barium in the hepatic ducts or a large solitary calculus with a facet. Air in the bile ducts must be a common finding as it was present in three of the four cases observed by the writer. Air shadows are usually tubular or branched, and follow the general direction of the common duct. Air may surround a calculus in the gall bladder and cause a crescentic shadow.

Upon two occasions the writer has observed tubular transparent shadows arising near the spine and extending downward from left to right. I can find no adequate explanation of these pseudo-air shadows. They may be due to fat in the ligamentum teres hepatis. One of these cases was operated upon for a perforating duodenal ulcer and no fistula was present.

Air or barium rarely enters the hepatic ducts except through a biliary fistula. Not infrequently one sees the opening of the



Fig 3-A

Fig 3 A Case 3 Pneumocholedochus with intestinal obstruction. Note the small crescentic tubular air shadow in the hepatic region. This is undoubtedly air in the gall bladder apparently partially surrounding a calculus. Coils of dilated small bowel can be seen below. Diagnosis was confirmed at operation.

Fig 3 B Case 3 Complete spasm of the lower two-thirds of the stomach in case of pneumocholedochus. The stomach showed no evidence of relaxation when examined one hour later.

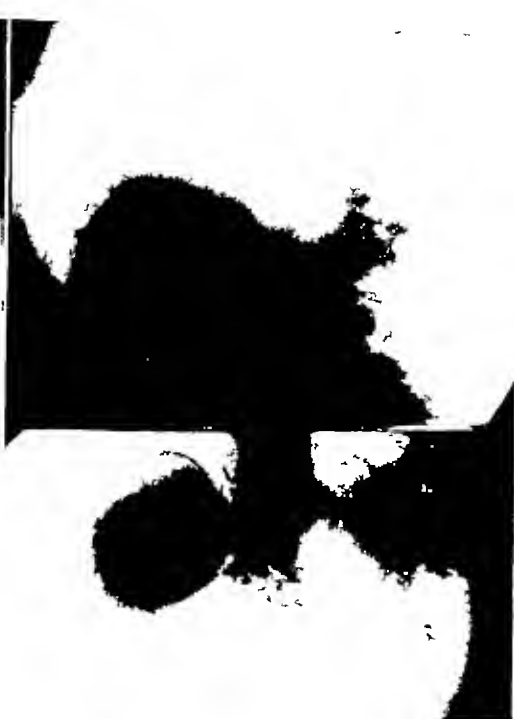


Fig 3 B

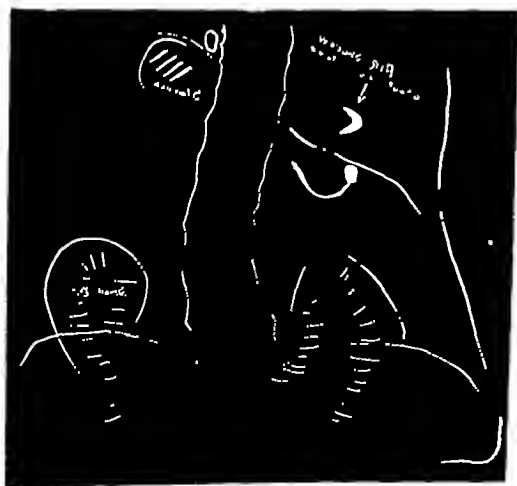


Fig 3 C Case 3 Diagrammatic sketch of the foregoing film. An indistinct air shadow may be seen surrounding the cylindrical stone in the gall bladder.

ampulla bluntly outlined, but barium is never seen to enter the duct. In case of a recently passed gallstone or malignant

infiltration, the ampulla may be gaping open, but to my best knowledge no such authenticated cases have been recorded.

Case 1 The first case observed by the writer, Mrs J C, was admitted to the Palo Alto Hospital on July 27, 1932. The attending physician stated that there had been at least two previous attacks of severe abdominal pain. Three days before admission the patient was seized with a severe attack of pain, nausea, and vomiting. This continued until admission, when the picture was that of intestinal obstruction. A flat abdominal film showed markedly distended coils of jejunum and the hepatic ducts beautifully outlined by air. At operation, a stone 4 cm in diameter was removed from the jejunum. The gall bladder was firmly adherent to the duodenum and, owing to the patient's condition, could not be freed. The woman made an uneventful recovery.

Case 2 One week following the pre-

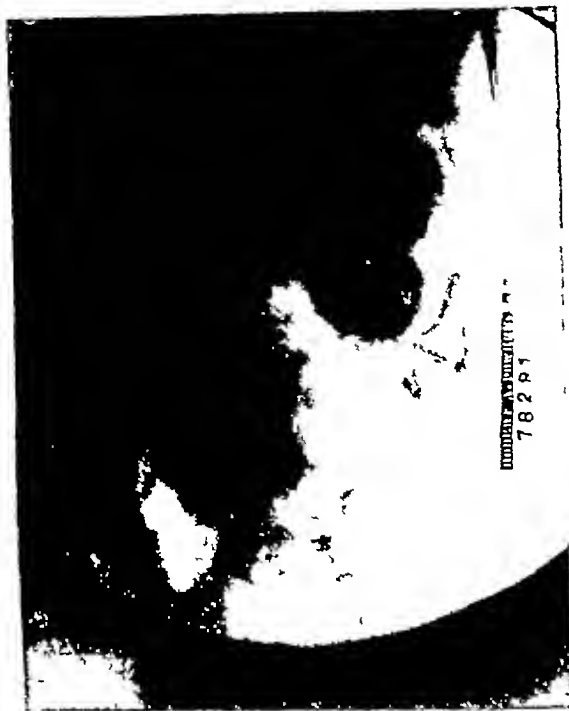


Fig 4-A

Fig 4-A Case 4 Spontaneous duodenocholecystostomy An enormous stone is present in the gall bladder One side of the stone is flattened, suggesting friction against another stone, of which there is no evidence An inferential conclusion of spontaneous duodenocholecystostomy was made The second stone was found in the small bowel



Fig 4-B

Fig 4-B Case 4 Spontaneous duodenocholecystostomy The upper stone was removed from the small intestine the lower one from the gall bladder There is an interesting difference in the calcium content of the two calculi

vious case, Mrs J J B was sent to the hospital for clinical study The patient had complained of sub-sternal pain of six months' duration, which was intermittent, lasting several days and then going away for a time It had been quite intense for three weeks, and sometimes radiated behind the left shoulder She had chills and a temperature of 100 degrees F She was always nauseated, and vomited by forcing herself She had lost 25 pounds in weight Three years previously she had been operated upon for appendicitis A plain gall-bladder film showed a tubular air shadow extending up into the hepatic area On barium meal examination, the barium was seen to extend up from the junction of the first and second portions of the duodenum, apparently into the gall bladder A translucent area suggested a cholesterol stone There was a large diverticulum arising from

the second portion of the duodenum At 6 and 24 hours, the supraduodenal pouch still retained barium

At operation there was found a marked hepatitis The pancreas was also swollen The gall bladder had shrunk until it was 1.5 cm in diameter and 2 cm long The cystic duct was atrophic The common duct was 2.5 cm in diameter, swollen, and contained a calculus 2 cm long and 1.5 cm in diameter A fistula extended between the common duct and the duodenum There was also a very small closed fistula between the common duct and the gall bladder At operation, the fistula into the duodenum was closed, the common duct opened, and the stone removed The gall bladder was removed, a tube inserted into the common duct for drainage, and a cigarette drain to Morison's pouch The patient had a stormy convalescence, drain-

ing bile for several weeks. She left the hospital on Sept 24, 1932, in fairly good condition.

Having observed hepatic air shadows in two cases in a single week, the writer looked up a case which had been examined several years previously. This patient, Mrs A C, had been admitted to the Palo Alto Hospital, May 7, 1923. A rather meager history stated that there had been vomiting for a week. Roentgen examination showed a marked narrowing of the entire stomach with the exception of the cardiac pouch. At 6 hours typical dilated coils of jejunum were observed. Roentgen diagnosis was intestinal obstruction.

A review of the films in this case shows a definite air shadow in the hepatic area. The air appears to be surrounding a cholesterol calculus. At operation, a large stone was removed from the intestine and another from the gall bladder, a fistula was found to be present between the gall bladder and the duodenum. The gall bladder was removed and the fistula closed. After an uncertain period of five weeks the patient was discharged in fairly good condition.

Air shadows in the hepatic tree probably occur quite frequently and, as many of these patients are too ill for the administration of barium, the air finding is probably of more clinical value.

Case 4. A fourth case, Mrs J C, was examined as an office patient on July 8, 1929. This patient, a Christian Scientist, had been ill for several days with nausea, vomiting, and pain in the right upper abdomen. Films of the gall-bladder area showed a large calculus 3.5 cm in diameter, the lower half spherical while the upper margin was perfectly flat. As the large calculus was faceted and no opposing calculus was present, a roentgen diagnosis of gall-bladder perforation was made. Being a Scientist, the patient temporized for three days, following which she was operated upon, although in a rather critical

condition. A large stone was removed from the lower ileum and another from the gall bladder. A fistula between the gall bladder and duodenum was closed and the gall bladder removed. As is usually the case with delayed intestinal obstruction operations, the patient died.

I have found no previous mention of a solitary faceted gall-bladder calculus being the basis for a diagnosis of biliary fistula. Such a diagnosis appears almost fool-proof, but it is possible that one stone might have a high calcium content and the other be almost pure cholesterol. In the case described above there was a minimum of calcium in the missing stone.

In intestinal obstruction cases, careful search should always be made for air shadows. If it is true that over 2 per cent of these cases are due to gallstones, it is remarkable that this observation is not more frequently made.

#### SUMMARY

In closing, I wish to emphasize the following points:

Internal biliary fistulae are probably much more prevalent than is generally believed.

In every case of intestinal obstruction, the hepatic area should be carefully searched for extra-intestinal air shadows.

A large solitary gall-bladder calculus having a facet usually means perforation.

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# PORPHYRINEMIA AND PORPHYRINURIA A WARNING REGARDING THEIR IMPORTANCE IN ROENTGEN THERAPY

By I S TROSTLER, M D , F A C R , F A C P , Chicago

HOW many radiologists recognize the importance of porphyria and the possible source of danger in the sensitization, by means of drugs, of the tissues to light? How many of you have had your attention called to this subject at any time?

Because of the rather recent introduction of hematoporphyrin (commercially known as Photodyne and other names) into general use in medical therapeutics, particularly in neuropsychiatry in the treatment of melancholia and allied depressive conditions, and the *decidedly too promiscuous taking and prescribing of barbituric acid derivatives as sleeping powders*, it is altogether likely that some radiologists may have reason to wonder why erythemas appear after moderate or even mild dosage.

I am calling your attention to this subject because I have had that experience myself and have been called to help another radiologist who had a scare because of the same thing.

As the result of a series of experiments with hematoporphyrin, to determine its photobiologic properties and effects, Hausman<sup>1</sup> reported, in 1916, that by hypodermatically injecting solutions of that agent, white mice, rats, and guinea pigs were rendered so highly sensitive to light that when they were exposed to it they became toxic and died, but when these same injected (control) animals were kept in the dark they were apparently unaffected.

Huehnerfeld<sup>2</sup> and others later reported that while animals so treated showed marked photodynamic effects when the hematoporphyrin was injected under their skin, no such effects resulted when the drug

was administered orally, except when large doses were given. Rats fed with large doses became toxic and died within three or four hours after being exposed to bright sunlight. These rats showed fatty degeneration of central liver lobules, *hyperemia of the skin* and other pathology.

Meyer-Betz,<sup>3</sup> while experimenting with hematoporphyrin, administered 0.2 gm under his own skin and then irradiated an area on his arm with a Finsen lamp, with a resulting ulceration in the irradiated area. Two months later he suffered a "light stroke," with the production of giant edema and deep pigmentation of the skin.

While the literature of the manufacturers of hematoporphyrin claims that this drug has no harmful effects, the proven fact that it sensitizes (and causes a sensitization) to light makes it very much worth our while to keep it in mind, because of the potential danger to our patients.

What appears to be more important to us as radiologists is that in addition to hematoporphyrin, many commonly used sedatives, such as sulphonal, luminol, and other barbituric acid derivatives produce porphyria and porphyrinuria, with the resultant sensitization to light and irradiation. These agents also cause itching, which occurring simultaneously with and accompanying skin redness is decidedly liable to give the unwary radiologist unpleasant insomnia and additional gray hairs.

I have seen three cases of what were to all external appearances roentgen erythema, one of which had been diagnosed as "x-ray burn" by a dermatologist, all of which were the result of the patients taking "sleeping medicine," at the same time that they were receiving roentgen therapy.

<sup>1</sup> Hausmann W. The Sensitizing Action of the Natural Porphyrins. *Biochemische Zeitschrift* 1916 77, 208.

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None of these cases recurred when the barbiturates were discontinued, even though the dosage of the roentgen rays was increased in two of the cases. I reported two of these in a communication to the "Journal of the American Medical Association" last April.<sup>4</sup> The third case is still under my observation, and is as follows:

A blonde woman of 30, while receiving roentgen treatment to relieve thyrotoxicosis, developed a definite redness over the treated area, one week after the application of 160 r delivered at 130 p kv through 3 mm aluminium. Inquiry from the physician who referred her disclosed the fact that she was taking luminol elixir in moderate dosage for her nervousness. This was immediately stopped and quinine

hydrobromid substituted. After the erythema had subsided, I administered 200 r and later continued the treatment with 260 r without any indication of overdosage.

My attention was first called to this sensitization by the barbiturates while searching for a line of defense in a malpractice suit which resulted from a roentgen dermatitis, and like many of the lessons learned in that manner, it came to the surface of what little intelligence I possess and presented itself when most liable to be needed.

Because of this, I am suggesting that all who do any radiation therapy remember that these drugs produce porphyrinemia and porphyrinuria, which, in turn, cause the tissues to be highly sensitive to irradiation.

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<sup>4</sup> Barbiturates and Irradiation. Jour Am Med. Assn, May 2, 1936, 109, 1588.

# WHAT IS THE BEST WAY IN WHICH TO TREAT BREAST CANCER?

By GENTZ PERRY, M D , *Evanston, Illinois*

ON Sept 2, 1935, I sent to the Diplomats of the American Board of Radiology, to a number of other prominent radiologists and surgeons, and to a considerable number of prominent physicians in general practice, 925 reprints of a paper entitled "X-ray and Radium Treatment of Cancer of the Breast,"<sup>1</sup> which I had read before the Illinois State Medical Society at Springfield, May 16, 1934. With each reprint I sent a letter in which I requested each physician receiving the reprint to answer certain questions and, in his reply, to state his viewpoint upon what he considers to be the best general means of treating breast cancer. Many interesting and instructive letters have been received in response from the physicians.

It is the purpose of this paper to make as careful and complete an analysis of these replies as a limited space will permit. A majority of the radiologists express themselves as being in accord with the ideas and propositions set forth in the reprints and letter, as to the technic and value of radiation therapy. They vary widely, however, in their views concerning the follow-up surgical care. On the other hand, a minority of the surgeons who have replied are in favor of the plan of treating cancer of the breast as outlined in the reprints. A majority of them state that they believe the complete removal of the breast and axillary lymphatic tissues to be the best means of getting rid of breast cancer. The replies received from internists and from physicians in general practice show a great majority of these latter groups to be in favor of the propositions set forth in the reprint, especially the plan and technic of thorough pre-operative radiation therapy.

The three basic propositions set forth in the reprint alluded to are

*Proposition 1*—A dosage of at least

<sup>1</sup> Ill St Med Jour, February 1935 67, 129-133

5,000 r, in air, in some cases more than this, delivered from an x-ray tube activated by a current of 200 kv or more potential,

## X-RAY FROM DIRECT ANTERIOR PORT

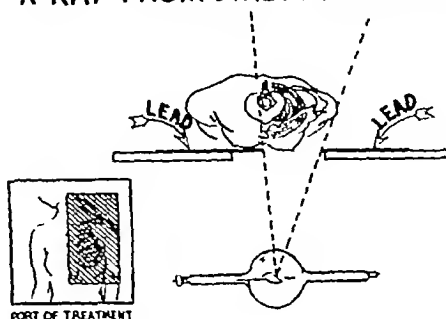


Fig 1

which x-ray passes through a filter of 2 mm Cu or its equivalent, the secondary radiation from this filter being absorbed by proper aluminum or other filters, and the whole dosage delivered by the cross-fire method through five portals of entry, as illustrated by the accompanying sketches. This radiation is to be delivered within a period of from two to four weeks, or as rapidly as may be done without causing a pronounced roentgen sickness (nausea, etc.) during the treatments, and without producing a too pronounced leukopenia or anemia.

These sketches, which show precisely how this dosage is delivered to a patient resting upon a standard treatment couch, from the x-ray tube in the couch under the patient, in all of the positions for treatment except the position for the doses of x-ray delivered directly downward through the top of the shoulder and base of the neck on the affected side, while the patient is sitting in an upright position (which doses are delivered to the patient from an overhead tube), are published with the hope of clarifying the general propositions. These are that the main portions of the x-ray doses are given through the breast, chest wall,

## X-RAY THROUGH SHOULDER, ETC., FROM ABOVE

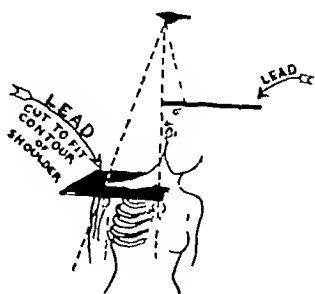


Fig 2

## X-RAY THROUGH POSTERIOR PORT

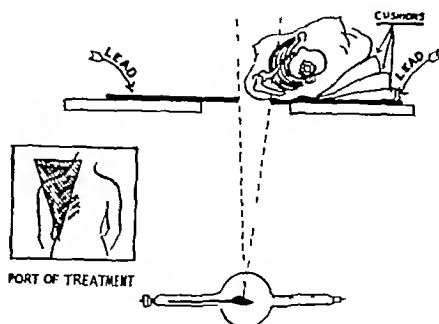


Fig 3

and shoulder only, and in such position as to be tangential to the ribs under the areas treated, and that only about one-fifth of the entire dosage is sent directly through the entire chest of the affected side, including the mediastinum. In the average ordinary case, we give 500 r, usually in three doses, to the patient when she is in the position shown in Figure 1.

In three or four doses, 600 r are given to the patient from the position shown in Figure 2.

At least 2,000 r is given to the patient when placed as shown in Figure 3, and in this position we aim to have the treatment aperture so arranged that these x-ray doses given from the posterior port go through the base of the neck, the entire shoulder, and the entire chest wall down to the waistline. The average patient will be nauseated if more than 180 r is given in each dose to this large area.

In doses of 200 r each, 1,000 r or more are given to the patient when in the position shown in Figure 4.

In doses of 200 r each, 1,000 r or more are given to the patient when in the position shown in Figure 5.

Ordinarily, the doses of x-ray are alternated regularly through the different fields in the sequence of their numbers. Usually the first vesication will appear upon the skin of the axilla. In the average case treated, this vesication will be rather general over the entire front chest wall, shoulder, etc., in from six to fourteen days after

the treatments are finished. These blistered areas are treated by soft linen sterile pads of several thicknesses, kept constantly moist with a 2 per cent magnesium sulphate solution in distilled water, for a period of ten days. The pads are changed frequently enough to absorb all of the serum exudate from the inflamed surfaces. Following these moist pad dressings, all of the affected skin areas are sprayed twice daily by means of a strong atomizer, or by a nebulizer, with a mixture of equal parts of 01 Ricini and 01 Olivæ, and the entire surface is then covered with a light, sterile, soft linen cloth loosely fastened about the chest. The incision lines of the immediate follow-up surgery are usually covered by strips about two inches wide of several thicknesses of plain sterile gauze, or such other gauze as the surgeon may prefer, and these two-inch strips of dressing are changed rather frequently in order that they may be renewed as soon as they have become partially saturated from the serum exuding from the vesicated areas.

These same measures may be accomplished with practically any treatment apparatus, provided sufficiently thick lead shields are so placed as to bisect the central rays coming from the tube and shielding the portions of the patient's body that should not receive the x-rays. The anatomical variations of the patients and the location and extent of the cancer make it necessary to vary the relative positions of the patient, the lead shield, and the tube to

## X-RAY THROUGH EXTERNAL LATERAL PORT

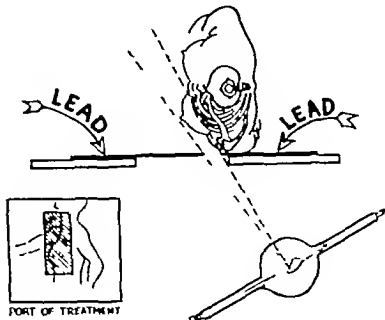


Fig 4

some extent, but the basic proposition that but one-fifth of the total x-ray dosage is sent directly through the lung of the affected side is and should be, followed in all cases in which proper x-ray films show the lungs to be free from visible metastases

*Proposition 2*—The interstitial use of highly filtered, or screened, radium placed within, or through, any remaining hard cancer masses that may exist immediately after the finish of the x-ray series of treatments, it being fully understood that the use or non-use of radium in each individual case be left entirely to the discretion of the radiologist

*Proposition 3*—Surgical removal of the diseased breast *immediately* after the radiation therapy has been finished. A further point was stressed in the reprints that, unless there are remaining hard and plainly palpable masses in the axilla of the affected side, no surgical invasion of the axilla is to be done, that we are to rely entirely upon the radiation therapy to sterilize the axilla, clavicular regions, etc., from malignancy

Classifying the replies mathematically, we have the following. There were 391 replies up to May 5, 1936, 192 of these letters are from radiologists, 79 are from surgeons, and the remaining 120 are from physicians in general practice, internists, etc

Of the radiologists, 31, or 16 per cent of those from whom we have received letters, agree almost entirely with the propositions set forth in the reprints that we mailed to them. Twenty-eight per cent of the radiolo-

## X-RAY THROUGH FRONT DIAGONAL PORT

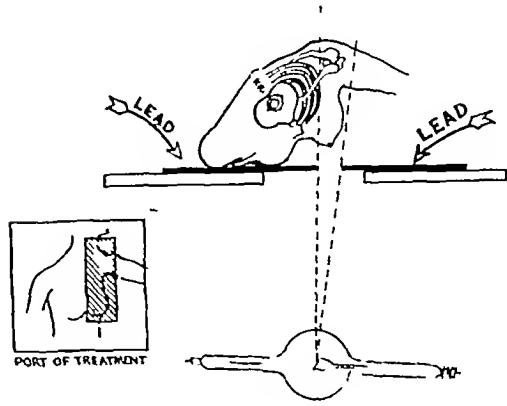


Fig 5

gists favor the same radiation therapy but differ as to the time of doing the follow-up surgery. Thirty per cent favor the use of x-ray only and nothing else. Twenty-four per cent of the radiologists prefer the use of lower voltage and smaller dosage. Two per cent favor the use of radium only.

Of the surgeons, 40 per cent are in favor of pre-operative x-ray treatment. Eighteen per cent are in favor of both pre-operative and post-operative treatment. Thirty-one per cent are in favor of surgical operation first, to be followed by x-ray treatment. Two per cent favor radium treatment first, to be followed by operation. One surgeon writes that he is not in favor of any radiation therapy unless a recurrence follows the operation, and then he advises the use of radium only. About 8 per cent of the surgeons expressing themselves apparently have no confidence whatever in radiation therapy of any kind at any time.

From the physicians in general practice, internists, etc., we have 120 letters showing that 72 per cent are in favor of pre-operative radiation therapy to be followed by surgical operation, and about one-fifth of these same physicians express themselves as being in favor of post-operative radiation therapy also. Eight per cent of these last-named physicians favor surgery first, to be

followed up by x-ray treatment. Eleven per cent express their preference for surgical treatment only and are not in favor of any radiation therapy at any time. Nine per cent are in favor of treatment of breast cancer solely by x-ray.

There is only one point upon which all of the letters agree 100 per cent insofar as they express themselves on this point, and that is that the earlier these cases are seen and properly treated according to their own viewpoints, the better is the chance for successful eradication of the disease. The general impression one gets from a careful study of these letters is that the treatment of breast cancer is receiving an increasing amount of careful study and attention from the medical profession. Many of the letters clearly express important facts relative to the age and physical conditions of the patient as these factors influence the prognosis in each case. A further significant fact brought out in the study of these letters is that the first-named group of 31 radiologists who, for the most part, fully agree on the pre-operative radiation treatment producing marked skin reactions as set forth above, embrace some of our most successful radiation therapists. However, very few have mentioned any surgical

technic. Of course, we leave the surgical technic to the surgeon.

A question that arises in the study of these cases is whether or not the timid use of insufficient dosage by some radiologists may not constitute one of the causes why the other members of the medical profession are more or less skeptical about the value of radiation therapy. In this matter of proper dosage, permit me to quote the following paragraph from the extremely interesting and practical editorial by Dr. George W. Grier in the April number of RADIOLOGY:

"Incidentally, I might mention that Coutard treatment always produces what is commonly called an x-ray burn, with blistering and ulceration of the skin. This is a necessary part of the treatment and results cannot be obtained without it. Yet in some of our States the courts still hold that the presence of an 'x-ray burn' is *prima facie* evidence of neglect."

Permit me to take this opportunity heartily to endorse the editorial by Dr. Orville N. Meland, "Should the Patient be Told?" which appeared in the December, 1934, number of RADIOLOGY. I believe that every normal-minded patient should be informed exactly as to the nature of the condition before the treatments begin.

# CALCIFIED MESENTERIC LYMPH NODES THEIR INCIDENCE AND SIGNIFICANCE IN ROUTINE ROENTGEN EXAMINATION OF THE GASTRO-INTESTINAL TRACT

By SAMUEL SCHECHTER, M D , *New York City*

## INTRODUCTION

THE presence of calcified mesenteric lymph nodes is frequently noted in the course of roentgen examination of the gastro-intestinal tract. The relationship of these nodes to the symptomatology in these cases is often not clearly ascertained. This relationship is the object of this study.

## MATERIAL AND INCIDENCE

For a number of years I assisted Dr John L. Kantor in a series of "Colon Studies," which were published in a series of papers in the "American Journal of Roentgenology and Radium Therapy," from 1926 to 1934. The material collected for these studies (routine roentgen gastro-intestinal surveys) was also utilized for this present paper. A total of 2,119 cases was reviewed, from which were culled 35 cases in which calcified mesenteric lymph nodes were demonstrated roentgenographically (an incidence of 1.7 per cent).

It is interesting to compare these figures with the incidence of calcified nodes observed in radiographs of the lumbosacral spine and of the urinary tract. Through the kindness of Dr Raymond W. Lewis, roentgenologist at the Hospital for Ruptured and Crippled, New York City, I reviewed the radiographs of 1,000 consecutive cases of lumbosacral spine, and through the kindness of Dr Ross Golden, roentgenologist at the Presbyterian Hospital Medical Center, New York City, I reviewed the radiographs of 1,000 consecutive cases of examination of the urinary tract.

The spine films were taken for purely orthopedic conditions, and the films of the urinary tract were taken for suspected calculi in the kidneys or ureters. I found an incidence of 1.9 per cent of calcified nodes in the former and 2.8 per cent in the latter.

The incidence in the entire 4,119 cases reviewed was 2.1 per cent. This is a considerably lower figure than that reported by other investigators but is close to the figures noted in autopsy material.

The incidence reported by others is as follows:

(1) Strombeck, of Stockholm, in 1932, reviewed radiographs of 600 cases, chiefly adults, who were treated for various affections of the back and kidneys. He found calcified mesenteric nodes in from "7 to 8 per cent of the cases."

(2) Auchincloss states that Dunham found calcified mesenteric nodes in 128 children out of 1,152 (or 11 per cent) routinely x-rayed.

(3) Dunham and Smythe, of New Haven, in 1926, report that 17 per cent of 120 children with positive tuberculin tests had x-ray evidence of calcified mesenteric nodes.

In contrast to the incident findings in radiographic material, the incidence of calcified mesenteric nodes in autopsy material quoted by Golden and Reeves is as follows:

(4) Opie, of St. Louis, in 1917, reports not a single case in a series of necropsies on 93 children and 50 adults.

(5) Hof, of Kiel, Germany, in 1903, in a study of necropsies on 7,203 children and 7,683 adults, found tuberculous mesenteric

TABLE I—SITE OF CALCIFIED NODES

Region	Level	Cases	Percentage
R L Q	Third lumbar to second sacral	21	60.0
L L Q	Third lumbar to second sacral	5	14.3
Periportal	Above third lumbar right	6	17.1
Midline	First sacral	2	5.7
Bilateral	Third to fifth lumbar	1	2.8
		35	99.9

lymphadenitis, with no evidence of tuberculosis elsewhere in the body, in 1.4 per cent of children and 0.8 per cent of adults.

(6) Bietzke, in the Berlin Pathological Institute, found 0.9 per cent in 1,100 necropsies.

*Sex*—The cases in our study revealed only a slight difference in the sex incidence. 54.3 per cent were males and 45.7 per cent were females.

*Age*—The age group distribution was as follows:

- 1 year to 10 years—1 case
- 11 years to 20 years—0 case
- 21 years to 30 years—15 cases
- 31 years to 40 years—10 cases
- 41 years to 50 years—5 cases
- 51 years and over—4 cases

Sex and age incidence conform in the main to the incidence of these factors in the unselected series of gastro-intestinal cases.

#### SITE OF CALCIFIED NODES

In Table I is indicated the site of the calcified nodes. The preponderance of cases in which the nodes are localized in the right lower quadrant of the abdomen is in accord with the findings of other observers.

#### SYMPTOMATOLOGY

The symptoms presented by the 35 patients in our series were those that would

TABLE I.—SITE OF CALCIFIED NODES, LOCALIZATION OF PAIN AND TENDERNESS, AND OTHER X-RAY FINDINGS

Case	Site of Nodes	Pain	Tenderness	Other X ray Findings
1	R U Q	Both costal margins	Epigastric	Duodenal ulcer
2	Bilateral R and L L Q	None	None	Spastic colon dyschezia
3	R L Q		R L Q	Spastic colon
4	R L Q			Cecal stasis high cecum
5	R U Q		L L Q	Low cecum pulm tbc
6	L L Q	Epigastric	L L Q	Gallstones
7	R L Q	Substernal	None	None
8	L L Q	R L Q		Diverticulosis (colon)
9	L L Q	R L Q	R U Q	Simple colitis
10	R L Q	None	None	None
11	Midline, 1st sacral		R L Q epigas tric	Nephrolithiasis spastic and redundant colon
12	Midline 1st sacral	R L Q	R L Q	Simple colitis
13	R L Q	None	None	Ulcerative colitis
14	R L Q	R U Q	R L Q	Simple colitis
15	R L Q	R L Q	R L Q	None
16	L L Q	L L Q	None	Simple colitis
17	R L Q	L U Q	L U Q	G B disease simple colitis
18	R L Q	R L Q	R L Q	Simple colitis
19	R U Q	None	None	Low cecum duodenal bands
20	R U Q	General abdominal discomfort		Simple colitis
21	L L Q	None		Low cecum
22	R U Q			Visceroptosis
23	R L Q			Low cecum
24	R L Q	Epigastric L L Q	L L Q	Low cecum
25	L L Q	Navel	R L Q	Simple colitis
26	L L Q	R U Q	Slight over liver	Gastro enterostomized for D U
27	R L Q	Epigastric	None	Duodenal ulcer
28	R U Q	None	R L Q	Low cecum dyschezia
29	R L Q		L L Q	Diverticulosis simple colitis
30	R L Q	L L Q	None	Redundant colon
31	R L Q	None		Low cecum, delayed gastric emptying
32	R L Q			Redundant colon
33	R L Q	Epigastric	R L Q and L L Q	Simple colitis
34	R L Q	None	Both costal margins	Simple colitis
35	R L Q	L L Q	L L Q	Simple colitis

suggest the advisability of a roentgen study of the gastro-intestinal tract and may be divided into two groups, local and general. The most prominent local symptoms were abdominal pain and tenderness, and the chief general symptoms were nausea and vomiting.

*Abdominal pain* was present in 19, or 54.3 per cent, of the cases. This is only slightly above the general incidence of abdominal pain, which is 47 per cent. A fairly marked increase was noted, however, in the incidence of right lower quadrant pain, which was present in 17 per cent of the cases and compares with a general incidence of only 9 per cent.

*Abdominal tenderness* was present in 18, or 51.4 per cent, of the cases. This is a marked increase when compared with the general incidence of 29.7 per cent. The incidence of right lower quadrant tenderness, however, was only 25.7 per cent against a general incidence of 19 per cent.

*Nausea and vomiting* were present in 15, or 42.9 per cent, of the cases, a striking increase when contrasted with a general incidence of 20 per cent.

One may conclude from the above that the cases in our series showed a somewhat increased percentage incidence of both local and general symptoms. It is, of course, appreciated that, when dealing with such a small number of cases, the figures obtained may be misleading. Therefore, as a check, a study of the other findings in the roentgen examination of these 35 cases was made. This showed

that, in a large number of cases, co-existent roentgen abnormalities were present that could be considered adequate cause for these symptoms.

Table II correlates the local symptoms of abdominal pain and tenderness with the site of the calcified nodes and the presence or absence of other roentgen findings.

A summary of Table II shows the following:

10 cases, or 28.5%, with no abdominal pain or tenderness.

2 cases, or 5.7%, with abdominal pain and tenderness localized at site of nodes.

1 case, or 2.8%, with abdominal pain but no tenderness at site of nodes.

1 case, or 2.8%, with abdominal tenderness but no pain at site of nodes.

3 cases, or 8.6%, with abdominal tenderness at site of nodes but pain not at site of nodes.

5 cases, or 14.3%, with abdominal pain and associated tenderness but not at site of nodes.

3 cases, or 8.6%, with abdominal pain and tenderness differently localized and not at site of nodes.

5 cases, or 14.3%, with abdominal pain but no tenderness and not at site of nodes.

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Further condensing of this table shows that in only four, or 11.4 per cent, of the cases there was localization of pain, tenderness, or both at the site of the calcified nodes. In three, or 8.6 per cent, of the cases there was abdominal tenderness at

TABLE III

Case	Site of Nodes	Nausea or Vomiting	Other X ray Findings
2	Bilateral R and L L Q	Nausea	Spastic colon, dyschezia
5	R U Q	Vomiting	Low cecum pulm tbc
7	R L Q	Vomiting	None
9	L L Q	Nausea and vomiting	Simple colitis
10	R L Q	Vomiting	None
11	Midline first sacral	Nausea and vomiting	Nephrolithiasis spastic and redundant colon
12	Midline first sacral	Vomiting	Simple colitis
14	R L Q	Nausea	Simple colitis
15	R L Q	Vomiting	None
16	L L Q	Vomiting	Simple colitis
17	R L Q	Vomiting	Gall bladder disease simple colitis
26	L L Q	Nausea	Gastro enterostomized for D U
27	R L Q	Vomiting	Duodenal ulcer
31	R L Q	Nausea and vomiting	Delayed gastric emptying, low cecum
34	R L Q	Nausea	Simple colitis



the site of the nodes but pain elsewhere. In the remaining 28, or 80 per cent, of the cases, pain and tenderness were either absent or not localized at the site of the calcified nodes. Of the four cases with pain or tenderness at the site of the nodes, only one had no other roentgen abnormality than the calcified nodes. This case was operated upon and the calcified nodes removed.

Of the 18 cases in which abdominal pain, tenderness, or both were present but not localized at the site of the calcified nodes, all but three cases revealed adequate cause for the presence of these symptoms.

The symptoms of nausea and vomiting were similarly analyzed. Table III correlates these general symptoms with the site of calcified nodes and the presence or absence of other roentgen findings.

A summary of Table III shows that in only three, or 20 per cent, of the cases in which nausea, vomiting, or both were present, were any other roentgen abnormalities found, whereas in 12, or 80 per cent, of the cases other roentgen findings were noted that may be considered adequate cause for their presence. One of the three cases was the previously mentioned case that was operated upon and was found to have localization of pain and tenderness at the site of the calcified nodes. The other two were cases of gastro-intestinal neuroses.

These statistical symptom analyses suggest that the following conclusion may be drawn *viz*, abdominal pain and tenderness, which are considered outstanding symptoms in the clinical evidence of calcified mesenteric lymph nodes, do not bear this symptom relationship when these nodes are found in routine roentgen studies of the gastro-intestinal tract. The same conclusion seems to be warranted in regard to the general symptoms of nausea and vomiting.

This conclusion is somewhat supported by the follow-up evidence. After institution of medical treatment, a follow-up of the 25 patients who complained of abdominal pain and tenderness revealed the

TABLE IV—APPENDECTOMY IN CALCIFIED MESENTERIC LYMPH NODE CASES

Appendectomy	11 cases	or 31.4%	(general incidence, 17%)
Clean cases	9	or 88%	
Pus cases	2	or 18.2%	(general incidence, 16%)

following, in periods ranging in some cases from as short a time as three months, to one as long as eight years.

Improved	13
Unimproved	2
No follow up data	9
Died following septic meningitis	1
	<hr/> 25

In one case the follow-up revealed an increase in size of the node calcification. It measured  $\frac{3}{16}$  of an inch in diameter at the first examination and  $\frac{5}{16}$  of an inch six years later. This node was present in the periportal region in a case of duodenal ulcer. The two unimproved cases were followed up for only a very short time and then were lost track of.

#### APPENDECTOMY

As might be expected, in view of the high incidence of right lower quadrant pain, 17 per cent (general incidence, 9 per cent), and the high incidence of nausea and vomiting, 42.9 per cent (general incidence, 20 per cent), a large percentage of the cases in our series was appendectomized. In all the cases the operation was performed prior to our roentgen study of the gastro-intestinal tract. Though the incidence of appendectomy is markedly increased, the percentage of pus cases is almost exactly the same as that of the general incidence as shown in Table IV.

#### SUMMARY

(1) Calcified mesenteric lymph nodes were found in 17 per cent of 2,119 routine gastro-intestinal roentgen surveys.

(2) Comparative incidence findings are 19 per cent in 1,000 consecutive cases of lumbosacral spine radiographs, and 28 per

cent in 1,000 consecutive cases of urinary tract radiographs

(3) In 60 per cent of the cases the site of the calcified nodes was in the right lower quadrant of the abdomen

(4) An increased percentage incidence of both local and general symptoms is noted, but relation to calcified lymph nodes is not apparent

(5) A large percentage of the cases, 80 per cent in this series, revealed either absence of abdominal pain and tenderness or localization of these symptoms at sites other than that of the calcified nodes Of this number, 28.5 per cent had no abdominal pain or tenderness

(6) Abdominal pain and tenderness, which are considered outstanding symptoms in the clinical evidence of calcified mesenteric lymph nodes, do not appear to bear this symptom relationship when these nodes are found in routine roentgen studies of the gastro-intestinal tract The relationship to the general symptoms of nausea and vomiting is also indefinite

(7) Appendectomy is frequently performed because of the high incidence of right lower quadrant pain and of nausea and vomiting

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<sup>1</sup> This brief list includes only the more recent publications For an extensive bibliography and especially for foreign literature, reference should be made to Strömbeck's monograph

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The symptoms of nausea and vomiting were similarly analyzed. Table III correlates these general symptoms with the site of calcified nodes and the presence or absence of other roentgen findings.

A summary of Table III shows that in only three, or 20 per cent, of the cases in which nausea, vomiting, or both were present, were any other roentgen abnormalities found, whereas in 12, or 80 per cent, of the cases other roentgen findings were noted that may be considered adequate cause for their presence. One of the three cases was the previously mentioned case that was operated upon and was found to have localization of pain and tenderness at the site of the calcified nodes. The other two were cases of gastro-intestinal neuroses.

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#### SUMMARY

(1) Calcified mesenteric lymph nodes were found in 1.7 per cent of 2,119 routine gastro-intestinal roentgen surveys.

(2) Comparative incidence findings are 1.9 per cent in 1,000 consecutive cases of lumbosacral spine radiographs, and 2.8 per

cent in 1,000 consecutive cases of urinary tract radiographs

(3) In 60 per cent of the cases the site of the calcified nodes was in the right lower quadrant of the abdomen

(4) An increased percentage incidence of both local and general symptoms is noted, but relation to calcified lymph nodes is not apparent

(5) A large percentage of the cases, 80 per cent in this series, revealed either absence of abdominal pain and tenderness or localization of these symptoms at sites other than that of the calcified nodes. Of this number, 28.5 per cent had no abdominal pain or tenderness

(6) Abdominal pain and tenderness, which are considered outstanding symptoms in the clinical evidence of calcified mesenteric lymph nodes, do not appear to bear this symptom relationship when these nodes are found in routine roentgen studies of the gastro-intestinal tract. The relationship to the general symptoms of nausea and vomiting is also indefinite

(7) Appendectomy is frequently performed because of the high incidence of right lower quadrant pain and of nausea and vomiting

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# CASE REPORTS AND NEW DEVICES

## A SIMPLE DEVICE FOR X-RAYING EGGS OF THE DOMESTIC FOWL

B. J. MESSINGBERG *Chicago, Ill.*

From the Anatomical Laboratories, Loyola University School of Medicine

In x-ray work with bird eggs some sort of a device must be made in order to facilitate irradiation and eliminate experimental errors. Such construction must include a heating element for keeping eggs at incubator temperature while being irradiated, it must include a candler for orientation of eggs for general as well as local irradiation, and it must be lead-insulated in order to absorb scattered rays. Further, it must be of simple construction and permit ease in handling. Such apparatus has been constructed and used in our laboratories for the last five years with considerable advantage.

### CONSTRUCTION

An ordinary wooden box of commercial design forms the framework of the device (Fig 1). It is of medium weight, and measures approximately 7.5 in. in width, 7.5 in. in height, and 15 in. in length. The top is covered with a sheet of lead  $\frac{1}{16}$  of an inch in thickness. At one end of the box is attached a cup-like structure while at the other is secured a wooden cross-bar. The cup is made of a lead strip, 13 in. long and  $1\frac{3}{4}$  in. wide, the ends of which are soldered together, shaped into an oval measuring approximately  $3\frac{3}{4}$  in. and  $4\frac{1}{2}$  in. in minor and major diameters. It is, in turn, soldered to the lead sheet covering the top of the box, and placed 5 in. from the end of the box to the center of the cup with equal distances from side to side. In the center of the cup, there is cut an egg-shaped opening,  $\frac{7}{8}$  by  $1\frac{1}{4}$  in., through the lead and the board. The longer axis of the cup and that of the opening coincide. That part of the lead sheet immediately surrounding the opening is bent upwards  $\frac{3}{16}$  of an inch. The cross-bar is provided with a V-shaped groove, forming an angle of  $90^\circ$ . The square bar of the tube carriage fits into this groove. The height of the bar plus the height of the box is such that when the carriage bar rests in the V-shaped groove of the cross-bar, it automatically determines the focal distance. The distance of the cross-bar from the lead cup is such that it will bring the mouth of the cup directly under the target of the x-ray tube.

The opening leading from the cup into the box is provided with a shutter, which is made of a lead sheet  $\frac{1}{16}$  in. in thickness and 3 in.

square. This square sheet of lead slides after the fashion of a gate-valve, in troughs provided on either side of the opening. The troughs are 6 in. long with one end closed and the other set against the board at the end of the box. At one end of the shutter, in the middle, a metal handle 4 in. long is attached. This provision enables the operator to manipulate the shutter in such a way that the opening can be completely closed or opened, as the occasion may demand.

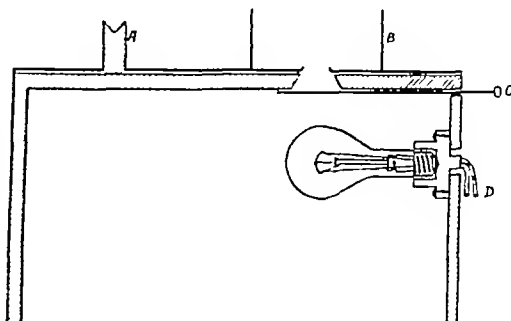


Fig 1 Irradiation box longitudinal section view. A Carriage rest bar B Lead cup C Shutter, D Electric light cable

Directly in line with the opening in the bottom of the cup, and immediately below the shutter, is placed an electric light bulb. A Keyle's receptacle is attached to the end of the box,  $1\frac{1}{2}$  in. below the top board. A 60-watt light bulb is used, as it is large enough to fit into the opening in the floor of the cup. A flexible cable extends through the board at the end of the box and is made long enough to facilitate connections. For convenience, two spools may be screwed on the side of the box on which the cord may be wound when not in use.

### OPERATION

The light in the box is turned on a short time before radiation of the eggs. A thermometer is placed in the lead cup, and while the heating process continues, the box is placed on the x-ray machine and connected with the tube carriage. In from ten to fifteen minutes, depending upon the temperature of the room, incubation temperature is reached and radiation may proceed. During radiation the temperature is regulated by turning the light on or off, as the case may be. We have found this satisfactory, and in case greater ease is desired, a thermostat can be inserted for that purpose. The light, besides serving as a heater, also serves as a candler. The egg is placed in

the cup, the shutter removed, and as the light is turned on, abnormalities in incubation can be detected readily. After candling, the eggs (three in number) are placed on the ledge of the cup, then the opening is closed by the lead shutter, and the eggs are irradiated. Thus the entire cup is made of lead which absorbs scattered rays and prevents the formation of secondary rays. In case local irradiation is desired, a piece of lead sheet with an opening in it to suit the purpose in view is placed on top of the cup, the candler in the box is used and, while looking through the opening in the top lead sheet, the places desired for radiation can be located. By this method the entire embryo is shielded except the spot to be exposed to the x-ray.

### AN INTRAMUSCULAR LIPOMA

#### CASE REPORT

By SAMUEL BROWN, M.D. and AARON GROLLMAN, M.D. Cincinnati, Ohio

Among the first to make a pre-operative roentgenologic diagnosis of a lipoma is Nicolas Tagliavacche (1), who describes a case of a sub-aponeurotic encapsulated fibrolipoma situated in the deltoid muscle. The author credits Bufalini with having called attention to the transparency of a lipoma in relation to the muscle tissue surrounding it, which results in a clear delimitation of the tumor. Another case is reported by P. Benini (2). The tumor was located in the region of the right lower ribs. The roentgenogram showed a sharply defined area of decreased density, upon removal, the tumor proved to be a lipoma.

The case to be reported is that of a man, aged 50 years. He was referred for an x-ray examination of the right lower extremity because of a hard lump on the mid-lateral aspect of the thigh. The patient stated that he had noticed the mass about one and a half years before. It was not painful and it had not increased in size. Examination of the thigh revealed a fullness in the mid-lateral portion which appeared to be quite firm. The mass was fixed to the underlying tissue but was not attached to the skin. There was no tenderness upon pressure.

A study of the roentgenogram revealed no abnormal changes in the femur. On the external aspect of the femur there was noted an oval shaped transparent shadow within the muscle tissue from which it was sharply delimited (Fig 1). The diagnosis of a lipomatous growth was made. The patient was operated upon by one of us (A. G.). The tumor was situated beneath the fascia lata, between the vastus lateralis and the biceps femoris, overlying the periosteum of the bone.



Fig 1 An intramuscular lipoma

It was easily shelled out from its bed. The pathologic report was that of a lipoma.

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### AN UNUSUAL CASE OF CALCIFIED BODIES IN THE MUSCULATURE OF THE ENTIRE BODY

By M. J. LESOFF, M.D. and S. SHULMAN, M.D., Far Rockaway, N. Y.

Roentgenologists, St. Joseph's Hospital

This case is reported because of the unusual and extensive radiographic findings which were discovered accidentally during the course of a routine examination.

M. C., a white female, aged 95 years, born in U. S., was admitted to the hospital because of pain in the right hip and back. She had suffered an injury to these regions about three weeks previous to her admission, and because of the persistence of pain and the development

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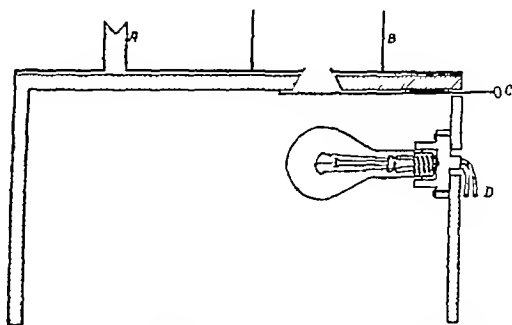


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of a cough it was felt advisable to send her to the hospital, although there were no definite signs of fracture. Physical examination re-

have been reported by Brailsford (1) and Connor (2). We were unable, however, to find a similar case involving practically all the muscles



Fig 4

Fig 5

Figs 4 and 5 Radiographs of upper and lower extremities showing distribution in the musculature

vealed a very senile female who could not cooperate in giving information regarding either her present or past illnesses. There were no definite physical findings other than moist râles at the bases of both lungs and the changes incident to senility.

Because of the history of trauma, she was referred to the x-ray department for an examination of the pelvis and hips. There was no evidence of fracture. There were seen to be present numerous discrete calcified shadows covering practically the entire pelvis. Additional films were then made of the chest, abdomen, and extremities, which revealed similar calcified shadows. (See Figures 1 to 5.)

**Radiographic Report**—The radiographic examination of the entire body shows countless numbers of discrete calcified shadows, ovoid in shape, varying in size from one eighth to one-half inch, and with their long axes in the same plane as the part involved. They appear to be situated within the muscles. Because of their shape, size, and distribution, they probably represent some form of calcified parasites. Unfortunately, it was not possible to obtain a biopsy to ascertain the exact nature of these shadows.

#### COMMENT

Cases of calcified parasites in the soft tissues

of the body. In his recent book, Brailsford mentions several parasites which undergo calcification in the muscles, and gives a brief description of their appearance. These are as follows: *Echinococcus*, *Cysticercus cellulosæ*, *Trichina spiralis*, *Dracunculus medinensis*, *Oncocerca*, *Pentastoma*, and *Sarcosporidia*. As described by him, the calcifications in our case conform more closely to that of *Cysticercus cellulosæ* than to any of the others.

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#### CONGENITAL NON-UNION OF THE STERNUM

By F. N. HOFFMEIER, M.D., Washington County Hospital, Hagerstown, Maryland

It has been my good fortune to find a congenital deformity which, so far as I am able to learn, has not been reported.

Many congenital malformations result in no disability or loss of function and are unknown until picked up by x-ray. This was not the case with the patient in the present instance, as she knew she had "something different" and, when young, would amuse her playmates





Fig 1 Radiograph of pelvis showing calcified shadows distributed in the muscles of the gluteal region and upper thigh



Fig 2

Fig 2 Radiograph of abdomen showing distribution in the lumbar muscles



Fig 3

Fig 3 Radiograph of chest, showing distribution in the pectoral muscles

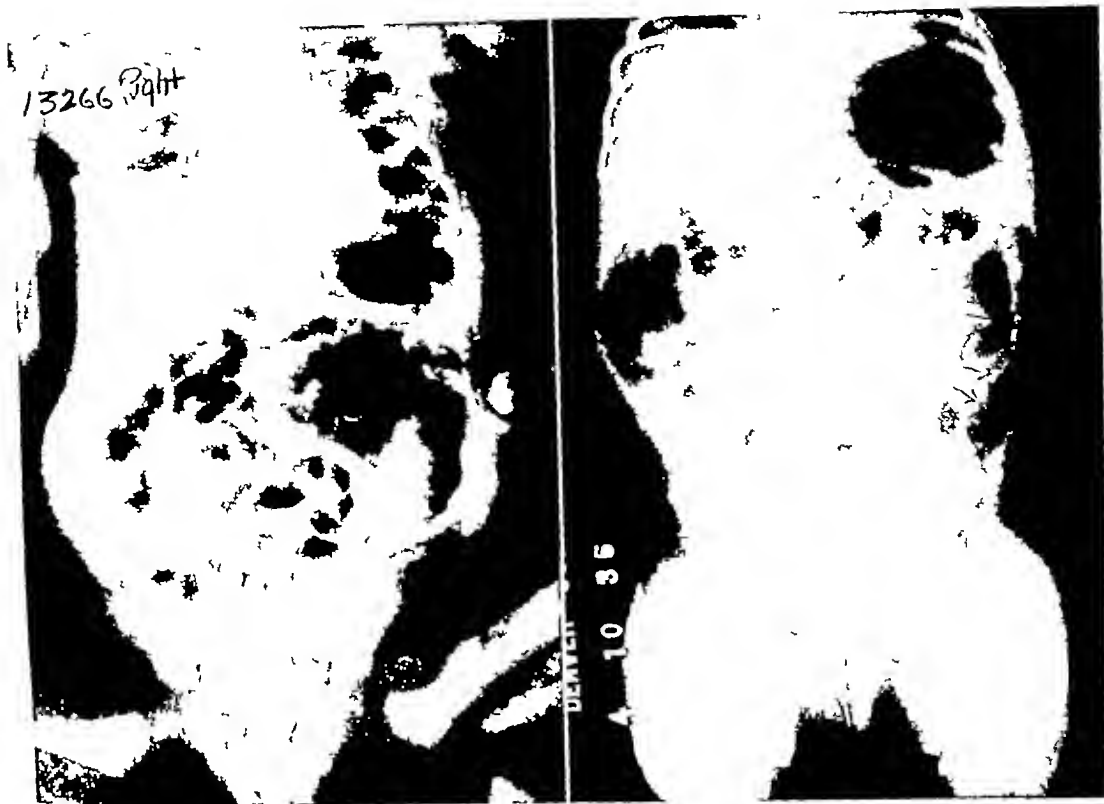


Fig 1

Fig 2

Fig 1 Case 1 Enema could not be forced beyond the hepatic flexure region

Fig 2 Case 1 Almost complete evacuation of enema at the four hour period demonstrates motility

Children's Hospital the first day after birth, April 9, 1935. He was given an x-ray examination the second day after birth. Cecostomy was performed the third day after birth. He died the fourth day after birth and an autopsy was performed. The roentgenologist's report was as follows:

*"Fluoroscopic Observations*—Barium enema entered slowly, and only under considerable pressure with a bulb syringe. The rectum was narrow and would not balloon out. The enema followed the normal course of a colon and was forced as far as the right upper quadrant, where its passage was blocked. The caliber of the column of barium was only about 4 mm throughout. *Films*—These confirm the fluoroscopic findings and show the small column of barium following the same course as a colon. This film (Fig 1), another four hours later (Fig 2), and one on the following day (Fig 3) show loops of gas distended bowel, with progressive increase of distention, indicating small bowel obstruction. One of these loops followed, more or less, the course of the colon and radiographically might be either the colon or small bowel. *Opinion*—Micro-

colon, probably with incomplete rotation, with cecum in the right upper quadrant, and obstruction near the ileo-cecal valve. Possible 'double-barrel' colon was not excluded."

#### EXCERPT FROM AUTOPSY RECORD

"The entire large bowel is greatly decreased in size, its diameter being 5 mm from the cecum down as far as the rectum. The terminal portion of the rectum, however, shows a marked increase of the lumen compared with the size of the large bowel. The large intestine shows a complete lack of haustration. The descending and transverse colon are in the usual location, while the cecum is moved to the mid-line and is located just beneath the edge of the liver somewhat to the right of the mid-line. There is a sudden increase in the size of the gut in the region of the cecum, measuring 20 cm in diameter, but beyond the cecum the terminal portion of the ileum shows again a decrease in size, measuring only 10 mm in diameter. Following the gut orally (*sic*) from that point, it appears that there is a gradual increase in the lumen so that at the junction of the ileum and jejunum it reaches 30 mm in diameter. The



Fig. 1 Film taken in the anterior posterior position face down



Fig. 2 Film taken in the oblique position right side down

by coughing for them. During the act of coughing her throat and upper chest distend in a spherical mass as large as an orange. This has never given her any inconvenience except for the bulging.

The patient, a female 33 years of age, was admitted to the hospital with empyema following an attack of influenzal pneumonia.

Her family history is negative—father and mother both living and well, one sister living and well, one brother died in infancy. Her personal history is essentially negative. She

had the common childhood diseases except mumps and whooping-cough, and is the mother of two children.

None of the living members of her family has any deformity, but her grandmother on her mother's side told her that one of their ancestors had some deformity the exact nature of which she did not know.

The roentgenograms reproduced herewith show a congenital non-union of the sternum from the sternal notch to the level of the third rib.

## MICROCOLON

### TWO CASE REPORTS

B<sub>3</sub> F B STEPHENSON, M D F A C R

Denver, Colorado

Microcolon is rare, Rankin, Barger, and Buie (1), in the 1932 edition of their book, refer to six definitely certain cases. In 1925, however, Greig (2), of Edinburgh, while reporting three cases, records a comprehensive study of the anomaly and gives statistical data derived from 28 cases. He comments on there having been found two cases in 111,451

Vienna autopsies, and nine cases in 150,000 Leningrad autopsies. The 75 references listed will furnish a complete bibliography to that date for anyone wishing to pursue the subject. The rarity of the anomaly makes it a coincidence worth noting that the following two cases were encountered within fourteen days of each other at the Children's Hospital, Denver, having been referred to the same Denver pediatrician. Both were diagnosed roentgenologically by opaque enema, and one proven by autopsy. Both showed incomplete rotation.

Case 1 J P, white, male, patient of Dr John A Schoonover, was admitted to the

Case 2 Baby L, white, male, admitted to the Children's Hospital when two days old, died when seven days old, there having been no operation nor autopsy. The baby passed no meconium after birth, vomited up to the fourth day, then passed several stools. Rectal examination revealed a narrow, funnel-shaped rectum. An x-ray examination by enema was made on the fifth day.

*Röntgenologist's Report*—"The bariumized enema passed just beyond the splenic flexure, where considerable resistance was encountered. The pelvic colon appeared very narrow. The sigmoid and descending portions of the colon were narrow and of irregular outline. *Films*—Films at this point confirmed the fluoroscopic observations, but showed the barium to have passed on transversely across the abdomen (Fig 4). Further injection was then done, and films showed a dilated bowel proximal to the splenic flexure, which could be partly colon and partly ileum, or all ileum. Definite gas-distended loops of small bowel were also present (Fig 5). *Opinion*—Congenitally small descending colon, especially narrow within the pelvis, probably bound down by congenital bands, possibly short colon, ending at splenic flexure—at least not extending proximal to the hepatic flexure. Signs of small intestinal obstruction."

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## MULTIPLE MALIGNANCIES OF HEAD AND NECK

### THREE INDEPENDENT LESIONS IN ONE PATIENT

By ASA B. FRIEDMAN, M.D.<sup>1</sup> and MATTHEW G. GOLDEN, M.D.<sup>2</sup> *New York City*

The subject of multiple primary carcinomas has been repeatedly studied and adequately reported. Shields, Warren and Olive<sup>3</sup>

recently published an excellent review of cases, 1,259 in all, in the literature as well as of their own sources. Since then a few other reports have appeared, increasing somewhat the total number of reported cases. Many and bizarre combinations of primary malignancies are included in these large sources, but the particular coincidence of neoplasms that the case to be discussed presented was not included. The reader is referred to the paper of Warren and Gates for an excellent analytical review of the subject to date.

T. C., aged 64 years, was referred to the Cancer Division at Kings County Hospital, on June 8, 1934. His chief complaint was pain, of not more than seven weeks' duration, on the left side of his tongue which radiated toward his left ear and was aggravated by swallowing. For eight months previous to this he had been treated in the Medical Clinic for arteriosclerotic cardiorenal disease. His past history was irrelevant except for the fact that it showed that he had received treatment, in 1930, at another hospital for a laryngeal newgrowth, and that he had remained under the care of that institution until November, 1932. His family history was negative for carcinoma or other so-called "familial" diseases. A report from the other hospital stated that the patient had been treated in June, 1930, for an extrinsic carcinoma of the larynx reported pathologically as epidermoid carcinoma, transitionally Grade Two, moderately radiosensitive. He was given 28,000 mc-hr of radium externally to each side of his larynx and the equivalent of 760 mc-hr of radium treatment from gold seeds placed in the left pyriform sinus.

At the time of his first visit to our Clinic, physical examination showed the following. A rather obese, adult, white male, aged 64 years. His heart, lungs, abdomen, and extremities were essentially negative except for moderate signs of arteriosclerosis. Laryngeal examination by one of us showed an essentially normal larynx. Both cords moved normally. There was no evidence of recurrent or residual growth, and very little evidence of scarring. On the middle third of the left lateral border of his tongue there was an indurated, ulcerated, neoplastic lesion, well demarcated. The tonsillar pillars and tongue base were not involved.

Biopsy was reported by Dr. Hala, attending pathologist, as follows: "Section is one of tongue, including portion of the muscles. In some places the mucous lining is hypertrophied, with marked acanthosis and keratinization of the cells; elsewhere, there is ulceration, and the presence of numerous irregular islands of varied size consisting of large squamous epithelial cells showing here and there a tendency toward pearl formation. This growth infil-

<sup>1</sup> Visiting Radiation Therapist, Kings County Hospital, Division of Cancer, Department of Hospitals, New York City. Dr. Ira I. Kaplan, Director.

<sup>2</sup> Attending Otolaryngologist, Kings County Hospital.

<sup>3</sup> WARREN, SHIELDS, and GATES. OLIVE. Multiple Primary Malignant Tumors. *Am Jour Cancer* 1932, 16, 1358-1414.



Fig 3

Fig 3 Case 1 Roentgenogram taken at 36 hours Note the smaller size of the column of barium demonstrates contractility



Fig 4

Fig 4 Case 2 Enema forced past the splenic flexure with difficulty



Fig 5 Case 2 Continued pressure of enema caused it to enter the proximal dilated bowel probably the ileum

drain tube mentioned above is inserted in one of those distended guts. Stomach and duodenum appear essentially negative. Upon the exploration of the heart it appears that the right ventricle is considerably enlarged and the musculature hypertrophied. Further examination discloses a large opening existing between the two auricles which is not merely a patency of the foramen ovale, but an incomplete development of the inter-auricular wall.

*'Diagnosis*—Congenital microcolon, incomplete development of the inter-auricular septum"

*Points of Especial Interest*—(1) The co-existing heart anomaly, (2) the hereditary factor. The baby was sent into the hospital because the attending physician, knowing that an infant brother of the patient had had an anomalous colon from which he died, feared that the failure of the patient to pass meconium indicated a similar anomaly. It was later learned that an infant son of the father's sister had died due to a colon anomaly. Thus, an infant boy, his brother, and a cousin all died soon after birth due to anomalous colons.

48 hours in Standard Methods Formula (1.5 per cent nutrient agar, 3 grs beef extract, 5 grs peptone per liter), and plate counts were made from a dilution of from 1 to 10,000. The bacterial count (all types) was then as follows: untreated milk, 4,800,000, ten-minute sample, 11,000,000, fifteen-minute sample, 13,500,000, twenty-minute sample, 11,500,000.

All four samples, when kept in covered glass bottles over a three-day period, seemed to conform to the finding in the initial experiment. Fluid in the irradiated milk separated much sooner than in the untreated, and the rate and amount of separation appeared to correspond roughly to the treatment times. The irradiated milk, at the end of three days, showed many large air-pockets, and the curd was more

solid and compact than in the unirradiated milk. As before, the control gave off the characteristic lactic acid odor, while the treated samples gave evidence of butyric acid. However, no test was made for the type of acid present.

The experiment was not carried further because of lack of time and facilities for exact dosage measurement. No theory was formed as to whether the effect found was due to a direct stimulation of bacterial growth or was caused by some photochemical change which made the surrounding medium more favorable for the support of such organisms.

If the effect found in this brief work could be developed further, it might well be used as a biological indicator of  $\gamma$ -ray dosage.

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trates in some areas into the muscular zone  
*Diagnosis* Squamous-cell carcinoma of the tongue "

There were no palpable sub maxillary or cervical glands

*Treatment*—Because of the fact that radiation had previously been given to the neck, only the primary lesion was treated, x-ray treatment of the neck now being omitted. Six radium element needles (2 mg, 3.2 cm, 0.5 mm platinum) were inserted perpendicularly into the tongue, being equally spaced about the periphery of the palpable lesion. They were sown in place and allowed to remain 96 hours, giving a total dose of 1,152 mg-hr. The expected radium reaction resulted, and the lesion healed with excellent epithelization of the area and a minimum amount of post-radium pain. The patient remained entirely well for over five months. On Nov. 1, 1934, on examination, a small indurated ulcer about 7 mm in diameter was found on the lower edge of the right margin of the tongue. The entire lesion and the surrounding portion of the muscle was removed by an electrocoagulation loop. The base of the wound was then coagulated thoroughly. This specimen was reported by the pathologist as follows

"The normal mucosa to a large extent is absent as a result of ulceration, it is replaced by a new growth of the epithelial type which infiltrates downward into the substance of the tongue, reaching the muscular strata in some areas. The growth is composed of squamous, polygonal, and large round epithelial cells rather closely packed, small nests of them being separated by a rather delicate reticular stroma, there is no attempt at full differentiation. Epithelial pearls are absent and the keratinization has not occurred, many of the cells show hyperchromatic nuclei and occasional mitotic figures are observed. From the histologic standpoint the tumor appears to be highly malignant. *Diagnosis* Epidermoid carcinoma of tongue "

The periphery of the coagulated wound was then implanted with radium needles. The procedure was similar to that used in the first tongue lesion. A total dose of 600 mg-hr was given and the wound healed.

About six months later the patient was readmitted to the medical service because of an acute bronchial pneumonia. He died after admission. Autopsy was refused but the examination at the time did not show recurrence of the malignancy.

## IRRADIATION OF MILK BY X-RAYS

By ROBERT C. WOODS *Old Lyme, Conn.*

Following is a report of a short experiment on the treatment of milk by x-rays, carried out by the writer at the Gray Industrial Laboratories, Newark, N. J. All bacterial counts were done by I. R. Asen, Director of the Clinical Laboratory, Newark, N. J.

The x-ray machine used in this work was designed and operated primarily for industrial applications, and so, unfortunately, there was no method of calculating the actual dosages given in terms of r units or other measurements. This work is then of interest mostly because of the general effects obtained. The equipment used consisted of an ordinary 150 kv generator with a half-wave, mechanical rectifier operating a universal, medium focus, Coolidge air cooled x-ray tube. The tube was run at 38 kv, 5 ma, and the distance from target to surface of milk was 32 cm, no filter was used.

To determine roughly the chances of obtaining some effect by irradiation of raw milk, a 150 cc sample of raw milk was exposed to the x-ray beam in a sterile cardboard container for ten minutes, a control sample of 150 cc being kept in a like container at as near the same temperature as possible. After a 48-hour incubation period, the number of bacteria

groups in the treated milk was quite evidently larger than in the control, although no exact count was made at this time. Samples of treated and untreated milk, allowed to stand for seven days in covered sterile glass bottles, presented a marked difference in appearance. The irradiated milk showed a much more distinct cleavage of fluid from curd than the control, and gave a rancid, butyric acid odor instead of the normal sour-milk, lactic acid odor emitted by the control. Fluid from both samples was filtered and tested for pH, but no difference was found, although it was noted that fluid from the treated milk appeared much clearer after filtering than that from the untreated.

The experiment was repeated with more samples at different dosages and with more care. Using the same factors (38 kv, 5 ma, 32 cm target-milk distance) three samples of raw milk, 150 cc each, were irradiated in sterile cardboard containers, a fourth sample being kept as a control. One sample was irradiated ten minutes, one fifteen minutes, and one for twenty minutes. Throughout the twenty-minute period, the room temperature was 80 F, the temperature of the room in which the control was kept remained the same, and the temperature in the x-ray beam rose from 80 F to 92 F.

The four samples were then incubated for

lished radiologists, but not forgetting or neglecting the desires of the younger men just entering the field of radiology. The Committee has attempted to give the radiologists of this country ample opportunity to present papers and clinics, feeling they are cognizant of the conditions under which our radiologists work, and their experiences and suggestions would be doubly valuable to the radiologists attending the meeting.

The Clinics have proved a popular feature of previous meetings, and, as you will note, Clinics are to be presented four afternoons during the meeting.

Dr James T Case, of Chicago, is to give the Carman Lecture and we are pleased to state that the members of the Cincinnati Academy of Medicine are to be guests of the Radiological Society on that occasion.

Many social activities have been planned by the local committee in Cincinnati and everyone will enjoy looking up old friends and acquaintances, and making new ones.

Looking forward to seeing you in Cincinnati, I am

Sincerely yours,

THOMAS A BURCHAM, M D, *President*  
*Chairman, Program Committee*

### CINCINNATI, THE HOST CITY

A few facts concerning the city in which the Annual Meeting of the Society is to be held may be interesting, as forming a background to a visit there.

Cincinnati has been an incorporated city since 1819. It is at present governed by nine councilmen, elected at large, who, in turn, elect a mayor to be the official head of the city for all ceremonial purposes. The council appoints the city manager, a trained administrator, who appoints and may remove all heads of departments and, subject to civil service provisions, is responsible for the appointment and removal of all other officers and employees in the administrative departments. The present city manager is Mr Clarence A Dykstra, student of political science and former member of the faculty of the University of California. Cincinnati's outstanding possession is her municipal government, she boasts of being 'the best governed city in America.'

The fact that the city has long been known as largely German in character is due to the



Tyler-Davidson Fountain on Fountain Square with the Hotel Netherland Plaza in the background

immigration of a group of Germans about 1840. They wrote back to their kinsfolk in 'the old country' that the Ohio Valley was 'another Rhine Valley in appearance and fertility.'

The city is served by eight trunk line railroads, and is 300 miles from Chicago. At one period, its river traffic was its main communication with the country east and west. Now, much of the travel and traffic from the central South passes through Cincinnati. There has recently been completed a modern railway terminal. A municipal airport is located near the central part of town.

The Annual Meeting is to be held in the Netherland Plaza Hotel, modern, and luxurious in every way. There are other excellent hotels of the first class within easy distances,



# EDITORIAL

LEON J. MENVILLE, M.D., *Editor*

HOWARD P. DOUB, M.D., *Associate Editor*

## ROENTGENOLOGIC SYNDROMES

Disease, when typical in form, manifests itself in the patient by cardinal symptoms and signs. These cardinal symptoms and signs have been recorded by the medical profession for decades, and, in the case of many diseases, for centuries. They have, as a result, become so definitely a part of their respective diseases that, when they are found in certain groups or syndromes, no question is asked as to the diagnosis. One symptom or sign does not make a diagnosis, but a typical syndrome of a disease, running true to type, leaves no doubt in the physician's mind. A chill, a sudden rise of temperature, a cough, bloody sputum, pain in the chest, percussion dullness over a localized area of the lung, truly indicates pneumonia. A physician's skill is measured by his ability to not only elicit certain symptoms and signs of disease but also by his ability to analyze the symptoms and signs and put them together in their correct relations to each other as pointing to a certain disease. That ability marks the great physician.

It is interesting that one disease can be so completely differentiated from another disease as to make its diagnosis easy, as one plant from another, but it is even more interesting that the reaction of the various anatomical structures to each disease can be so different. After all, when the physician elicits certain symptoms and signs he is determining definite structural changes of anatomy and must so interpret them.

The roentgenologist portrays upon a film the anatomy of a patient and the pathological

variations of this anatomy—structural changes indicative of disease. The skill of the roentgenologic physician is measured by his ability not only to evaluate these structural changes as pathological processes, but especially by his ability to put them together in definite groups as pointing to certain diseases—roentgenologic syndromes.

A roentgenologic syndrome can be as truly indicative of the structural changes of disease as any clinical syndrome. It does, however, require the knowledge of the clinical history to enable one to state that a given disease is the one which ails the patient. Gallstones and a diseased gall bladder might be demonstrated, a definite disease process, but the patient could be dying of leukemia.

The roentgenologic physician may become so engrossed in the demonstration of structural changes that he fails to grasp the larger significance of his findings. The demonstration of an irritable duodenum, a diseased appendix, and cecal stasis is important, but this roentgenologic syndrome may often mean an ulcer of the duodenum when a true ulcer deformity cannot be portrayed. Having succeeded in the accurate demonstration of anatomical changes and well along with the interpretation of these structural changes into terms of diseased processes, the roentgenologic physician can now begin to look forward to a greater grouping of roentgenologic syndromes as typical of certain diseases.

W. W. WASSON, M.D.

## ANNUAL MEETING, NOV 30—DEC 4, 1936

### TO THE RADIOLOGISTS OF NORTH AMERICA

In this issue of *RADIOLOGY*, you will find a Preliminary Program of the Annual Meeting of the Radiological Society of North America, to be held Nov 30 to Dec 4, 1936, in Cin-

cinnati, with headquarters at the Netherland Plaza Hotel.

The Program Committee has endeavored to arrange interesting papers and discussions for each day of the meeting, with the thought of giving as varied a program as possible, always planning to cater to the wishes of the estab-

J RYAN, M D, St Luke's Hospital, New York City

13 "The Rôle of the Vegetative Nervous System in the Clinical Roentgenology of the Upper Digestive Tract" ALFRED L C SIEFERT, M D, Oakland, Calif (20 min)

Discussion (5 min) to be opened by BYRL R KIRKLIN, M D, Mayo Clinic, Rochester, Minn

14 "Non-carcinomatous Tumors of the Stomach" RAY ALDEN CARTER, M D, Los Angeles, Calif (20 min)

15 "The Mobility of the Antrum, Pylorus, Duodenum, and Gall Bladder in Health and Disease The Influence of Mobility in the Functioning of These Organs in the Biliary Tract" NATHAN B NEWCOMER, M D, Denver, Colo, and ELIZABETH H NEWCOMER, M D, Denver, Colo (20 min)

Discussion (5 min) to be opened by ALFRED L L BELL, M D, Long Island College Hospital, Brooklyn, N Y

16 "Effects of Peptic Ulcer on Emptying of the Gall Bladder" EDWARD A BOYDEN, M D, Minneapolis, Minn (by invitation) (20 min)

17 "Primary Tumors of the Small Intestine" EDWARD W ROWE, M D, Lincoln Clinic, Lincoln, Nebr (20 min)

"Biliary Dyssynergia Disorders of Motility of the Extra-hepatic Biliary Tract" (to be read by title) HAROLD A HILLS, M D, San Francisco, Calif (by invitation)

### *Tuesday Afternoon*

2 00 P M

### EXECUTIVE SESSION

### *Hall of Mirrors*

Report of the Nominating Committee

3 20 P M

18 'Excretory Urography' JOSEPH B PRUESTLEY, M D, Des Moines, Iowa (by invitation) (20 min)

19 'The Roentgen Diagnosis of Lesions of the Upper Urinary Tract.' CARL L GILLIES, M D, University of Iowa, Iowa City, Iowa, and H DABNEY KERR, M D, University of Iowa, Iowa City, Iowa (20 min)

Discussion (5 min) to be opened by BERNARD H NICHOLS, Cleveland Clinic, Cleveland, O

### CARMAN NIGHT

### *Hall of Mirrors*

8 00 P M

*Wednesday Morning, Dec 2, 1936*

### *Hall of Mirrors*

9 00 A M

20 "Carcinoma of the Bronchus" LOUIS H CLERF, M D, Philadelphia, Penna (by invitation) (20 min)

Discussion (5 min) to be opened by LEO G RIGLER, M D, University Hospital, Minneapolis, Minn

21 "Osteopetrosis" R MANGES SMITH, M D, Dept of Roentgenology, Jefferson Hospital, Philadelphia, Penna, and AUSTIN T SMITH, M D, Dept of Rhinology and Laryngology, Jefferson Hospital, Philadelphia, Penna (by invitation) (20 min)

Discussion (5 min) to be opened by EDWARD L JENKINSON, M D, St Luke's Hospital, Chicago, Ill

22 "The Diagnosis of Parathyroid Dysfunction" EDGAR C BAKER, M D, Youngstown, O (20 min)

Discussion (5 min) to be opened by EDGAR M McPEAK, M D, Washington, D C (by invitation)

23 "Roentgen Methods of Studying the Soft Tissue Structures of the Neck" W EDWARD CHAMBERLAIN, M D, Temple University, Philadelphia, Penna, and ALBERT K MERCHANT, M D, Temple University, Philadelphia, Penna (20 min)

Discussion (5 min) to be opened by SAMUEL M BROWN, M D, University of Cincinnati, Cincinnati, O, and SAMUEL IGLAUER, M D, Professor of Otolaryngology, University of Cincinnati, Cincinnati, O (by invitation)

24 "Pulmonary Pneumocele Certain Considerations in Cystic Disease of the Lung" CARLTON B PEIRCE, M D, University of Michigan, Ann Arbor, Mich (20 min)

25 "Primary and Metastatic Pulmonary Malignancy Compared Clinically and Roentgenologically" JOHN T FARRELL, JR, M D, Jefferson Medical College, Philadelphia, Penna (20 min)

Discussion (5 min) to be opened by JOHN D CAMP, M D, Mayo Clinic, Rochester, Minn

### *Wednesday Afternoon*

2 00 A M

Symposium on the Female Pelvis  
Arranged by ROBERT A ARENS, M D, Chicago, Ill

among others, The Gibson, The Fountain Square, The Alms, and The Sinton. If you have not already made your reservation, you will assure yourself of more desirable accommodations by doing so at once.

## PRELIMINARY PROGRAM

### SCIENTIFIC PROGRAM of the TWENTY-SECOND ANNUAL MEETING of the RADIOLOGICAL SOCIETY OF NORTH AMERICA

November 30-December 4, 1936

Netherland Plaza, Cincinnati, Ohio

*Monday Morning, Nov 30, 1936*  
*Hall of Mirrors*

9 00 A M

Call to order THOMAS A BURCHAM, M D  
President of the Radiological Society

#### SCIENTIFIC SESSION

10 00 A M

1 "Surgical Anatomy of the Abdomen" (Illustrated with lantern slides) SAMUEL BROWN, M D, University of Cincinnati, Cincinnati, O (20 min)

Discussion (5 min) to be opened by SIDNEY LANGE, M D, Cincinnati, O (by invitation)

2 "Rare Developmental Abnormalities of the Adult Atlas" WALTER S LAWRENCE, M D, Memphis, Tenn (10 min)

Discussion (5 min) to be opened by BYRON H JACKSON, M D, Scranton, Penna

3 "Our Experience with Roentgen Examinations of University Freshmen during a Three-year Period" ERNST A POHLE, M D, Ph D, University of Wisconsin, Madison, Wisc (20 min)

Discussion (5 min) to be opened by HENRY KENNON DUNHAM, M D, Cincinnati, O

4 "Late Results in Traumatically Displaced Epiphyses" OSCAR LIPSCHULTZ, M D, Minneapolis General Hospital, Minneapolis, Minn (20 min)

Discussion (5 min) to be opened by LEO G RIGLER, M D, Minneapolis, Minn

5 "Roentgen-ray Evidence of Metastatic Malignancy in Bone" (Illustrated with lantern slides) HENRY SNURE, M D, Los

Angeles, Calif, and GEORGE D MANER, M D, Los Angeles, Calif (by invitation) (20 min)

Discussion (5 min) to be opened by W EDWARD CHAMBERLAIN, M D, Temple University, Philadelphia, Penna

*Monday Afternoon*

2 00 P M

6 "Cancer of the Thyroid in Children" HUGH F HARE, M D, Lahey Clinic, Boston, Mass (by invitation) (20 min)

Discussion (5 min) to be opened by U V PORTMANN, M D, Cleveland Clinic, Cleveland, O

7 "Radiotherapy in Catarrhal Deafness" FREDERICK J O BRIEN, M D, Boston City Hospital, Boston, Mass (20 min)

8 "Congenital Absence of the Left Diaphragm" MAX KAHN, M D, Baltimore, Md (20 min)

Discussion (5 min) to be opened by HOWARD P DOUB, M D, Henry Ford Hospital, Detroit, Mich

9 "Malignancy Involving the Duodenum" ALLAN TUGGLE, M D, New York Hospital, New York City (20 min)

10 "Roentgen Kymographic Studies in Clinical Cardiac Conditions" WENDELL G SCOTT, M D, Washington University School of Medicine, St Louis, Mo (by invitation) and SHERWOOD MOORE, M D, Washington University School of Medicine, St Louis (20 min)

11 "The Use of Pento-barbital Sodium (Nembutal) for Roentgen Stenosis Report of 175 Cases" EUGENE T LEDDY, M D, Mayo Clinic, Rochester, Minn, and W C POPP, M D, Mayo Clinic, Rochester, Minn (by invitation) (20 min)

*Tuesday Morning, Dec 1, 1936*

*Hall of Mirrors*

9 00 A M

Symposium on Diseases of the Stomach and Gall Bladder

Arranged by LEO HENRY GARLAND, M D, San Francisco, Calif

12 "The Incidence and Classification of Hernias" MAURICE F DWYER, M D, Seattle, Wash (20 min)

Discussion (5 min) to be opened by ERIC

26 "Value of Hysterosalpingography in Gynecological Diagnosis" ALBERT MATHIEU, M D, Portland, Oregon (by invitation) (20 min)

27 "A Comparison of Uterine Tubal Insufflation and Hysterosalpingography" LAWRENCE M RANDALL, M D, Dept of Obstetrics and Gynecology, Mayo Clinic, Rochester, Minn (by invitation) (20 min)

28 "Why Pneumoperitoneum?" IRVING F STEIN, M D, Chicago, Ill (by invitation) (20 min)

29 "Roentgenography in Obstetrics" J BAY JACOBS, M D, Washington, D C (by invitation) (20 min)

"Hereditary Multiple Ankylosing Arthropathy (Congenital Stiffness of the Finger Joints)" (to be read by title only) ARTHUR R BLOOM, M D, Detroit, Mich

30 "The Circular Area of Tuberculous Infiltration" CARL C BIRKEL, M D, Detroit, Mich, and J A KASPER, M D, Detroit, Mich (by invitation) (20 min)

Discussion (5 min) to be opened by HENRY K DUNHAM, M D, Cincinnati, O

*Thursday Morning, Dec 3, 1936*

*Hall of Mirrors*

9 00 A M

### Symposium on Therapy

Arranged by ARTHUR W ERSKINE, M D, Cedar Rapids, Iowa

31 "Radiation Treatment of Malignancy of the Lip" IRA I KAPLAN, M D, Director Radiation Therapy Service, Bellevue Hospital, New York City (20 min)

32 "A Study of Radium Technic in the Treatment of Carcinoma of the Rectum" HARRY H BOWING, M D, Section on Therapeutic Radiology, Mayo Clinic, Rochester, Minn, and ROBERT E FRICKE, M D, Section on Therapeutic Radiology, Mayo Clinic, Rochester, Minn (20 min)

33 "Peroral X-radiation in the Treatment of Intra oral Cancers" HAYES E MARTIN, M D, New York City (by invitation) (20 min)

34 "The Relation of Heredity and Environment to Cancer Occurrence" MAUDE SLYE, PH D, Sprague Memorial Institute, University of Chicago, Chicago, Ill (by invitation) (30 min)

35 "Cancer of the Breast" URSUS V

PORTMANN, M D, Cleveland Clinic, Cleveland, O (20 min)

36 "Practical Methods of Reducing the Cancer Death Rate" EDWARD H SKINNER, M D, Kansas City, Mo (20 min)

Discussion (10 min) to be opened by ALBERT SOILAND, M D, Los Angeles, Calif

*Thursday Afternoon*

2 00 P M

### EXECUTIVE SESSION

*Hall of Mirrors*

Election of Officers

3 20 P M

37 "Treatment Record Designation of the Tumor Dose in Roentgens" EDWIN C ERNST, M D, Barnard Free Skin and Cancer Hospital, St Louis, Mo (20 min)

38 "Should the Method of Coutard be Applied in All Cases of Cancer Treated by Roentgen Rays?" W EDWARD CHAMBERLAIN, M D, Temple University, Philadelphia, Penna, and BARTON R YOUNG, M D, Temple University, Philadelphia, Penna (by invitation) (20 min)

### Symposium on Gastroscopy

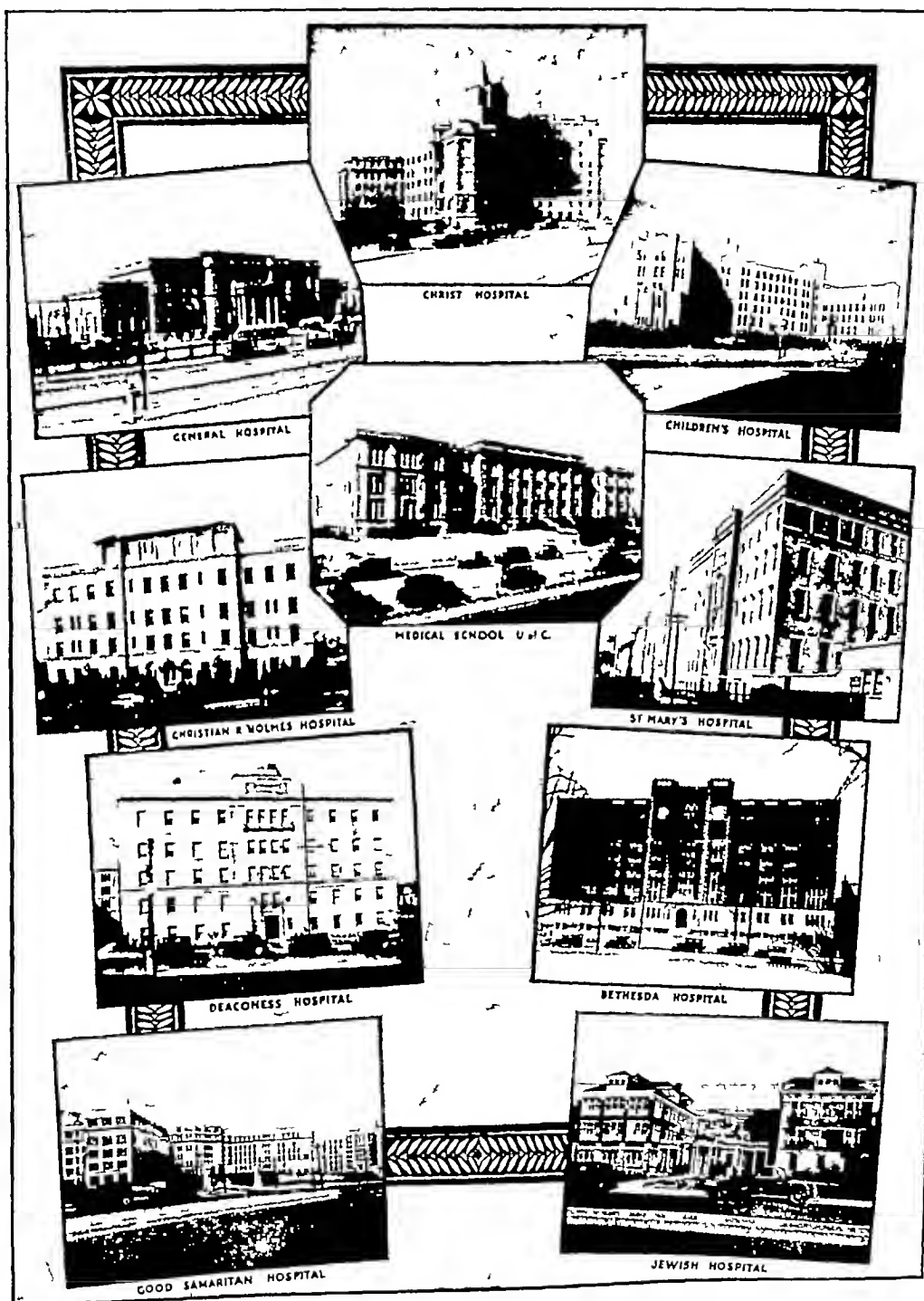
Arranged by LEO G RIGLER, M D, Minneapolis, Minn

39 "A Comparison of Gastroscopic and Roentgen Examinations" RUDOLPH SCHINDLER, M D, University of Chicago, Chicago, Ill, and FREDERIC TEMPLETON, M D, University of Chicago, Chicago, Ill (by invitation) (20 min)

40 "Gastroscopy" DR RICHARD SCHATZKI, Massachusetts General Hospital, Boston, Mass (by invitation) (20 min)

41 "The Value of Gastroscopy" EDWARD B BENEDICT, M D, Massachusetts General Hospital, Boston, Mass (by invitation) (20 min)

Discussion "A Critical Evaluation of Gastroscopy and Roentgenology in the Diagnosis of Diseases of the Stomach" BYRL R KIRKLIN, M D, Mayo Clinic, Rochester, Minn, and HERMAN MOERSCH, M D, Mayo Clinic, Rochester, Minn (by invitation)



Cincinnati's leading hospitals and the College of Medicine

Roentgen- or Gamma-ray Irradiation " EDITH H QUIMBY, M A , Memorial Hospital, New York City, and WILLIAM S MACCOMB, M D , Memorial Hospital, New York City (20 min )

Discussion (5 min ) to be opened by JAMES L WEATHERWAX, M A , Philadelphia General Hospital, Philadelphia, Penna

51 "Dosage Measurements with the Thimble Chamber" (by title) OTTO GLASSER, PH D , Cleveland Clinic Foundation, Cleveland, Ohio (20 min )

Discussion (5 min ) to be opened by LAURISTON S TAYLOR, PH D , Bureau of Standards, Washington, D C

## CLINICS

Clinics will be held every afternoon, with the exception of Thursday, from four to five o'clock

### AUTHOR

BYRL R KIRKLIN, M D , Rochester, Minn  
URSUS V PORTMANN, M D , Cleveland, O  
ROBERT B TAFT, M D , Charleston, S C  
WALTER W WASSON, M D , Denver, Colo  
MAX KAHN, M D , Baltimore, Md

(Round table discussion on interesting films cases, with abstract of history )

LEO H GARLAND, M D , San Francisco  
ARTHUR W ERSKINE, M D , Cedar Rapids, Iowa  
W EDWARD CHAMBERLAIN, M D , Philadelphia

WILLIAM E COSTOLOW, M D , Los Angeles  
GEORGE LYFORD, M D , Cincinnati, O  
PHILIP J HODES, M D , Philadelphia  
ZOE A JOHNSTON, M D , Pittsburgh

### TITLE

Cholecystography  
X-ray Treatment of Malignant Thyroid (Later)  
Differential Diagnosis of Pulmonary Diseases  
Bone Tumor  
Members, please bring films of your puzzling

Silicosis  
What does the Lesion Get?  
Radiologist's Part in the Problem of Low Back Pain  
Three Years' Experience with 500 kv  
Salpingography  
Pneumoconiosis  
Practical Treatment of Carcinoma of the Uterus by X-ray and Radium

## ANNOUNCEMENT

### FLORIDA STATE RADIOLOGICAL SOCIETY

The Florida State Radiological Society announces its officers for the ensuing year  
*President*, F J Payton, M D , of Miami Beach,  
*Vice-president*, G Raap, M D , of Miami,  
*Secretary*, Harold O Brown, M D , of Tampa

Meetings are held twice a year, in May and November

## COMMUNICATIONS

### AN IMPORTANT DECISION

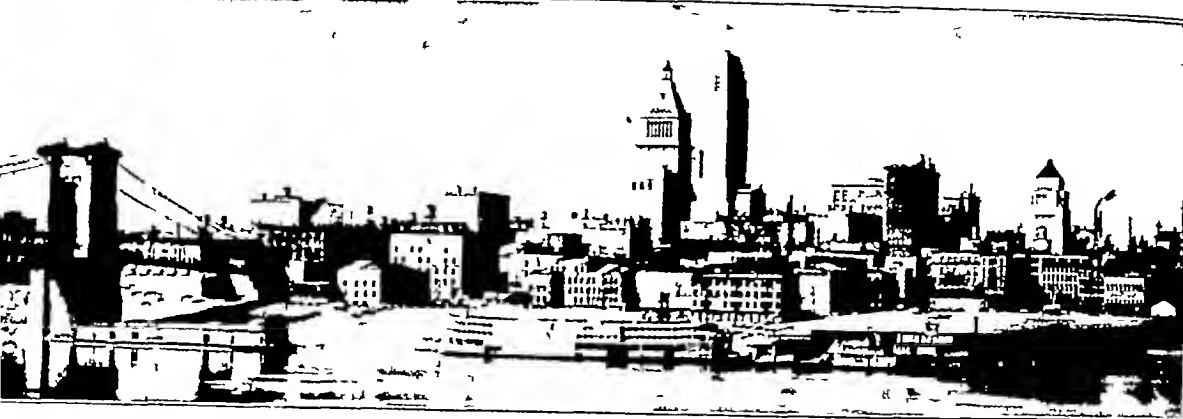
The following interesting communication has been received by the Editor from L Henry Garland, M D , of San Francisco, Secretary of the Executive Committee of the Pacific Roentgen Club

"In view of current comment concerning the recent Supreme Court opinion in this State on

the subject of nurse anesthetists, I think that the following facts should be brought to the attention of your readers

"The opinion in question has been publicized in the newspapers under the heading 'Lay Persons may Legally Give Anesthetics' The possibility of an analogous erroneous deduction regarding radiology is immediately apparent Now, the actual opinion states that a *Registered Nurse* may, under the *immediate direction* and *supervision* of the operating surgeon and his assistant, give an anesthetic The only application of this decision to radiology is that it might be construed to permit x-ray technicians to perform certain functions under the immediate and direct supervision of a radiologist However, there are definite regulations in this State dealing with the training and registration of nurses, but there are none dealing with x-ray technicians, hence, no direct analogy necessarily arises

"The decision in question was rendered following a series of rather unfortunate circumstances



The skyline of Cincinnati

*Friday Morning, Dec 4, 1936*

9 00 A M

*Symposium on the Chest*

Arranged by W WALTER WASSON, M D , Denver, Colo

42 (Five papers will make up this Symposium, titles and authors to be shown in the final program )

Discussion (5 min ) to be opened by HENRY K DUNHAM, M D , Cincinnati, O

47 "New Method for Examination of Sacro iliac Joints ' GAGE CLEMENT, M D , St Luke s Hospital, Duluth, Minn (20 min )

Discussion (5 min ) to be opened by JOHN BARNES, M D , Buffalo, N Y

48 "Traumatic Injuries of the Kidneys ' ROY P POTTER, M D , Marshfield Clinic, Marshfield, Wisc , and W G SEXTON, M D , Urologist, Marshfield Clinic, Marshfield, Wisc (by invitation) (20 min )

*Friday Afternoon*

2 00 P M

*Symposium on Physics*

Arranged by OTTO GLASSER, PH D , Cleveland Clinic, Cleveland, Ohio

49 "The Biological Action of Neutron Rays " JOHN H LAWRENCE, M D , Department of Internal Medicine, Yale University School of Medicine, New Haven, Conn (by invitation), PAUL C AEBERSOLD, M D , Division of Roentgenology, University of California Medical School, Berkeley, Calif (by invitation), ERNEST O LAWRENCE, M D , Radiation Laboratory, Department of Physics, University of California, Berkeley, Calif (by invitation) (20 min )

Discussion (5 min ) to be opened by KEN-

ETH E CORRIGAN, PH D , Harper Hospital, Detroit, Michigan (by invitation)

50 "Clinical Deductions from Physical Measurements on 200 kv and 1000 kv X ray Apparatus " ROBERT S STONE, M D , University of California Hospital, San Francisco, Calif, and PAUL C AEBERSOLD, M D , Division of Roentgenology, University of California Medical School, Berkeley, Calif (by invitation) (20 min )

Discussion (5 min ) to be opened by OTTO GLASSER, PH D , Cleveland Clinic Foundation, Cleveland, Ohio

51 "An Oil-immersed X-ray Generating Outfit for 500,000 Volts and an Oil-immersed Multi-sectional X-ray Tube " E E CHARLTON, PH D , Research Laboratory, General Electric Company, Schenectady, New York (by invitation), GEORGE HOTALING, Research Laboratory, General Electric Company, Schenectady, New York (by invitation), W E WESTENDORP, Research Laboratory, General Electric Company, Schenectady, New York (by invitation), L E DEMPSTER, Research Laboratory, General Electric Company, Schenectady, New York (by invitation) (20 min )

Discussion (5 min ) to be opened by ERNEST O LAWRENCE, Radiation Laboratory, Department of Physics, University of California, Berkeley, Calif (by invitation)

52 "X-ray Measurements with Liquid Ionization Chambers " LAURISTON S TAYLOR, PH D , Bureau of Standards, Washington, D C (20 min )

Discussion (5 min ) to be opened by G C LAURENCE, Canadian National Research Council, Ottawa, Canada

53 "Further Studies on the Rate of Recovery of Human Skin from the Effects of

*Method of Examination*

The examination required of candidates for certification as specialists in Internal Medicine will comprise, Part I (written) and Part II (practical or clinical)

*Part I* The written examination is to be held simultaneously in different sections of the United States and Canada and will include

- (a) Questions in applied physiology, physiological chemistry, pathology, pharmacology, and the cultural aspects of medicine
- (b) Questions in general internal medicine

The first written examination will be held in December, 1936, and candidates successful in this written test will be eligible for the first practical or clinical examination which will be conducted by members of the Board near the time for the annual session of the American College of Physicians at St. Louis in April, 1937. The second practical examination will be held at Philadelphia near the time of the annual session of the American Medical Association in Atlantic City in June, 1937.

The fee for examination is forty dollars, which must accompany the application, and an additional fee of ten dollars is required when the certificate is issued.

Application blanks and further information may be obtained by addressing the office of the chairman, Walter L. Bierring, M.D., 406 Sixth Avenue, Des Moines, Iowa, U.S.A.

**IN MEMORIAM**

ED. C. JERMAN, D.Sc.

Many members of the Radiological Society of North America will learn with sadness of the passing, on Sept. 13, 1936, of Mr. Jerman, so long and intimately identified with the x-ray industry. He was born in 1865, in Ripley County, Indiana, and during the course of his life travelled widely and made many friends. From 1918 until his retirement in 1934, he was engaged in educational work along the lines of technical procedure. Many of his written articles have been published by various medical, hospital, and x-ray journals, including a series of articles for *RADIOLOGY* and nearly a hundred "Service Suggestions". His first x-ray book was published during the early twenties, and an entire edition was soon sold. His second and best known x-ray book, "Modern X-ray Technique" (first edition, 1928), has been sold throughout the world, several printings being made in order to supply the



The late Ed. C. Jerman, D.Sc.

demand. It still is in demand, being used as a text-book by many teaching institutions. Two printings, translated into Spanish, have supplied the Latin-American countries. Intermittently during a period of five years, he conducted an original research study of the Egyptian and Peruvian mummies at the Field Museum of Natural History, Chicago. More than two thousand radiographs of various parts of nearly one hundred and fifty mummies were made in a pathologic study of these subjects. A monograph has been prepared and published by the museum as a result of the professional study of these radiographs.

Mr. Jerman was a charter member of the American Roentgen Ray Society, an associate member of the American Institute of Electrical Engineers for many years, an honorary member of the British Society of Radiographers, co-founder, President, and President Emeritus of the American Society of X-ray Technicians. For a period of eight years, he was examiner for the American Registry Board. He conducted the examinations of the first one thousand American and Canadian technicians to be registered by the American Registry Board. Since 1920 he travelled through more than thirty foreign countries, introducing his work of technical instruction.



First of all, the original suit was started by a small group of physician-anesthetists in Los Angeles, to enjoin and restrain a Registered Nurse from giving anesthetics in Saint Vincent's Hospital. The suit was not started by the official medical association of the State and it was not until after an unfavorable decision had been rendered in the lower court that the California Medical Association was asked to intervene. This it did unsuccessfully and at considerable expense. The main reason given by the Court for deciding in favor of the defendant lay anesthetist and the hospital was the nature of the testimony given by certain well-known surgeons on the staff. These surgeons testified that lay (nurse) anesthesia was an established and accepted practice in that hospital, they testified under oath that they *personally* directed the administration of the anesthetic during the operation!!! The Court was more impressed by this testimony than by any other. The surgeons now heartily regret having given the testimony that they did, but, apparently called to the defense of their institution by what seemed like a local case, they did their best to defend it and gave the testimony referred to. Since then, the case has assumed statewide and national proportions. These physicians now realize that it would have been better to have openly admitted that, in general, anesthetics should be given by duly licensed physicians, since the operating surgeon is usually far too busy to 'direct and supervise the anesthetist' even if he were able to do so, and that the administration of so dangerous a drug as an anesthetic is indeed the practice of medicine. For the information of those readers who are interested the actual opinion may be secured.<sup>1</sup>

"Now comes the question of trying to rectify matters. It is the opinion of some authorities that, if a suit were commenced on the merits of the case alone and not on the subject of enjoining any particular charitable institution from following certain practices, it would probably be successfully prosecuted. Unfortunately, such a suit would be an expensive undertaking and the California Medical Association is in no position to finance it at the present time. Perhaps the Sections on Anesthesiology of some of the larger state and national associations might pool some of their reserves and prosecute the matter as a joint constructive venture."

<sup>1</sup> By addressing Pacific Roentgen Club, 450 Sutter St., San Francisco

## THE AMERICAN BOARD OF INTERNAL MEDICINE (INC)

The American Board of Internal Medicine, incorporated Feb 28, 1936, completed its organization on June 15, 1936. The officers chosen were Walter L. Bierring, M.D., Des Moines, Chairman, Jonathan C. Meakins, M.D., Montreal, Vice-chairman, and O. H. Perry Pepper, M.D., Philadelphia, Secretary-Treasurer. These officers with the following six members constitute the present membership of the board: David P. Barr, M.D., St. Louis, Reginald Fitz, M.D., Boston, Ernest E. Irons, M.D., Chicago, William S. Middleton, M.D., Madison, John H. Musser, M.D., New Orleans, and G. Gill Richards, M.D., Salt Lake City.

The organization of the Board is the result of effective effort on the part of the American College of Physicians in conjunction with the Section on Practice of Medicine of the American Medical Association and these two organizations are represented in the membership of the Board on a five to four ratio, respectively.

The American Board of Internal Medicine had previously received the official approval of the two bodies fostering its organization, as well as that of the Advisory Board for Medical Specialties and the Council on Medical Education and Hospitals of the American Medical Association.

The purpose of the Board will be the certification of specialists in the field of internal medicine, and the establishment of qualifications with the required examination procedure for such certification.

While the Board is at present chiefly concerned with the qualification and procedure for certification in the general field of internal medicine, it is intended to inaugurate immediately after July 1, 1937, similar qualification and procedure for additional certification in certain of the more restricted and specialized branches of internal medicine, as gastroenterology, cardiology, metabolic diseases, tuberculosis, allergic diseases, *et cetera*. Such special certification will be considered only for candidates who have passed at least the written examination required for certification in general internal medicine. The operation of such a plan will require the active participation and co-operation of recognized representatives from each of such special fields of medicine.

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gaining relief of pain in two or three days and has been used as a diagnostic test in a limited series of cases

CHARLES G SUTHERLAND, M B (Tor)

## BIOLOGIC EFFECTS OF RADIATION

Experiments on *Drosophila melanogaster* Regarding the Influence of the High Frequency Field and Ether Anesthesia on Mutations Produced by Roentgen Rays and Gamma Rays of Radium A Pickhan N W Timoféeff Ressovsky and K G Zimmer Strahlen-therapie, 1936 56, 488-496

In a series of experiments on the fruit fly the authors determined the rate of mutations following exposure to certain doses of x-rays and radium An exposure of the test object to a 6-meter wave or ether anesthesia did not have any effect on the rate of mutations

ERNST A POHLE M D Ph D

## BONE DISEASES (DIAGNOSIS)

The Parathyroid Glands and Diseases of the Bones Editorial Jour Am Med Assn May 2 1936 106, 1566

Recent contributions to the literature covering this interesting subject are reviewed in such a manner as to correlate their subject matter with the existing knowledge and theories The skeleton in addition to being an inert supporting structure serves as a reservoir for calcium and phosphorus in which or from which these elements may be deposited or withdrawn according to the needs of the body The deposition of the quantity absorbed from the gastro-intestinal tract and the withdrawal of these elements is under the influence of the hormone secretion by the parathyroid gland Recent experiments seem to show that this substance plays a decisive part in the regulation of the calcium ion concentration of the blood Hypertrophy of the gland apparently results in an increase in the amount of parathyroid hormone secreted in the blood stream and thus produces demineralization of the bones Primary hyperparathyroidism is caused by a tumor of one or more of the parathyroid glands Secondary hyperparathyroidism signifies alterations in the structure and activity of the parathyroid glands encountered in certain bone diseases such as rickets, renal rickets and osteomalacia presumably representing a compensating response This has been observed in some cases of carcinoma with metastases to the bone, chronic nephritis nephrolithiasis, and multiple myeloma

CHARLES G SUTHERLAND M B (Tor)

## BREAST CANCER

The Treatment of Carcinoma of the Breast by Simple Removal of the Tumor Followed by Roentgen Therapy J Borak Strahlentherapie 1936 56, 200-204

During the last ten years the author has irradiated 26

women following simple removal of a carcinoma of the breast Nine out of the first 11 patients developed metastases The total doses amounted to from 1 000 to 2 500 r The next 12 cases received doses as high as from 3 000 to 6 000 r and only one recurrence developed These figures are based on a period of observation of one and one-half years During the same interval 80 per cent of the first group had bone metastases Technique two fields are usually given one over the anterior breast and one over the axilla The supraclavicular region is not irradiated Eight to fourteen days after the operation 12 sittings of 300 r each (170 kv, 0.5 mm Zn, 40 cm FSD) are given over one area and if the systemic reaction is not too severe, followed immediately by exposures over the second field Several photographs of a patient treated with this method in 1927 and still well to day are appended

ERNST A POHLE, M D, Ph D

## CANCER (THERAPY)

Roentgen Therapy of Carcinoma of the Hypopharynx Jens Juul and Ove Strandberg Strahlentherapie 1936, 56, 259-272

The authors relate their experience in the treatment of 49 cases of carcinoma of the hypopharynx A Coutard technique was employed 165-180 kv, 2-4 ma, Thoracis filter half value layer in copper = 1.5 mm, 50-70 cm FSD 2.5-5.0 r per minute 48-150 sq cm field size, two sittings per day It is quite essential that the general condition of the patient should remain good, the presence of heart disease is an undesirable complication Careful hygiene of the mouth should be stressed In the authors' experience the production of a confluent epithelitis in the mucous membrane is not absolutely necessary although this is emphasized by Coutard Of the 49 patients seen in the last four years 14 remained free from symptoms after the treatment, four were hopeless when entering 13 could not be completely treated 18 were only temporarily relieved

ERNST A POHLE M D Ph D

The Value of Klein's Reaction in the Treatment of Carcinoma W Dieterich Strahlentherapie, 1936, 56, 396-406

The author studied the test described by Klein for the recognition of cancer and the early diagnosis of a recurrence. A total of 409 patients with primary carcinoma and 76 patients with a recurrence were used for the investigation The principles of the method are described as follows Cell suspensions of certain animal cancers or sarcomas of equal age are treated in the same manner and added to the serum of the patient to be examined The cells are counted at the beginning of the test and after a certain time. A comparison of the two figures obtained permits certain conclusions which lead to a positive or negative diagnosis In order to rule out mistakes due to the personal error of counting the microscopic fields are photographed and thus a permanent record is established In the author's investi-

## ACTINOMYCOSIS

Roentgen Therapy of Actinomycosis S Kerjser  
Strahlentherapie, 1936, 56, 449-455

During the period of 1920-1935 a total of 101 patients with actinomycosis were treated in the author's clinic. Sixty nine patients had cervical involvement, 27 abdominal involvement, and in five the lesions were located in the thorax and other parts of the body. Technique of roentgen therapy: 170-180 kv, 0.5 mm Cu, 30-60 cm FSD, 75-85 per cent of the skin erythema dose per field. In about 50 per cent of the patients, one series was sufficient, in the others it was repeated after from six to eight weeks. Radiation therapy was combined with the oral administration of 6 grams of KJ daily. Injections of "Iudin" (antimone preparation) were also tried and proved to be effective occasionally. Of the 69 patients with lesions in the cervical areas, 67 were cured or are close to it at this time and only two died. Of the 27 patients with abdominal involvement, nine were cured. Of the last group of five cases, only one was cured, the other patients died. Further study of the use of the antimone in the treatment of actinomycosis is recommended.

ERNST A. POHLE, M.D., Ph.D.

## APPARATUS

A Brace for the Transportation and Handling of Patients with Injuries of the Cervical Vertebrae Louis T. Wright Jour. Am. Med. Assn., April 25, 1936, 106, 1467, 1468

This brace was designed primarily to allow roentgenographic examination without interference in the lateral and anteroposterior exposures. It is so solidly and firmly constructed that it will not slip when once applied. It is adjustable, and any degree of hyperextension and traction on the head is easily obtained by means of four turnbuckles. The chin piece is so arranged that it can be turned down out of the way when one finds it necessary to take a roentgenogram through the open mouth. It is capable of being applied at the scene of an accident and valuable in the transportation of a patient.

CHARLES G. SUTHERLAND, M.B. (Tor.)

Roentgen Therapy with Super high Voltage Apparatus Albert Soland Strahlentherapie 1936, 56, 521-525

The author briefly describes an 800 kv generator, operating a tube at 400 kv, with a filter of 8 mm of lead. At a tube current of 4 ma, the output is 15 r per minute. As several advantages of super high voltage therapy, particularly from a practical standpoint, the author lists the following: the systemic reaction is less than with the conventional 200 kv therapy when comparing equal depth doses, the skin erythema is milder, there is less influence of the time factor, several patients can be treated at the same time, the therapeutic

effects manifest themselves more quickly and deep seated malignancies are much more thoroughly destroyed than with the usual 185 kv technique.

ERNST A. POHLE, M.D., Ph.D.

Roentgenographic Control of the Central Ray in Deep Therapy G. Herrnheiser Strahlentherapie, 1936, 56, 437-448

The author analyzes the various sources of error which may occur when adjusting the ports of entry in x-ray deep therapy. He outlines the advantages which are gained by fluoroscopic control of the treatment fields and describes the principles of its application.

ERNST A. POHLE, M.D., Ph.D.

Radiation Therapy through a Lattice with Square Holes: The Importance of the Untreated Interspace." B. Grynkrant and W. Sitkowski Strahlentherapie 1936, 56, 413-421

The authors constructed several lattices with square holes using 2 mm of lead. Tests were then undertaken with the ionization chamber in air. The loss of intensity with 100 kv. was 20 per cent and with 180 kv., 6 per cent. Other tests on photographic film, on rabbits and on human skin were also carried out. The erythema on the human skin was milder if the lattice was used, provided equal doses were applied to skin areas with and without the lattice. It is concluded, therefore, that the tolerance of the skin is increased by means of the lattice and higher doses can be applied without permanent skin damage. What effect the use of this method has on the radiation absorbed in the inner organs is being studied.

ERNST A. POHLE, M.D., Ph.D.

## ARTHRITIS

Pain in the Shoulder Girdle, Arm and Precordium Due to Cervical Arthritis Samuel S. Hanflig Jour. Am. Med. Assn., Feb. 15, 1936, 106, 523-526

The syndrome of cervical arthritis, more often the hypertrophic variety associated with pain referred to the shoulder and arm and more rarely to the precordium in a pseudo-angina fashion, is common. The author regards the pain as a manifestation of irritation or actual inflammation (radiculitis) of cervical spinal nerve roots by arthritis.

The experimental work of Nathan suggested such an explanation. The nerve roots may be involved by adhesions or pressure of soft tissue swelling or by pressure of osteophytes with their associated soft tissue inflammation and synovial thickening. Symptoms may vary from paresthesias and numbness to severe pain along any of the sensory or segmental nerves depending on the degree of mechanical interference with the roots as they emerge from the cord.

Treatment by stretching and manipulation using a Sayre sling suspension apparatus, followed by graded exercises in rotation, flexion, and extension showed be-

sure relationships within the cranial cavity are not disturbed, since the liquid cushion on which the brain is borne does not have to be removed in order to obtain a clear film. There is no immediate discomfort and usually no sensation at all.

The greatest danger in the use of the method seems to lie in the inflammatory effects in cases in which the ventricular system is obstructed. In their work the authors have not met with any disastrous results following the retention of thorium in the ventricular system. From published reports, the introduction of the material into the basal cistern is accompanied by some danger, a few deaths having been reported.

Ventriculograms afford a complete outline of the ventricles in favorable cases. In no case have the authors used more than 6 cc of the thorium dioxide. When the ventricle is found with difficulty and only a few drops of fluid are obtained it is still possible to secure satisfactory roentgenograms. The taking of satisfactory films is facilitated by the perfect co operation usually possible on the part of the patient.

In 20 cases there were two deaths and two severe reactions. The authors' first patient is in his usual health twenty months after the injection.

CHARLES G. SUTHERLAND, M.B. (Tor.)

## DEFICIENCY DISEASES

Multiple Specific Nutritional Deficiency Disease in the Adult. Russell L. Haden. Jour Am Med Assn. Jan 25 1936 106, 261-265.

Specific nutritional deficiency disease represents abnormalities arising from a lack of the specific elements in nutrition which are normally supplied by the food or are formed directly from food in the gastro intestinal tract. In the present state of our knowledge the more important specific substances the lack of which leads to nutritional defects in the adult are (1) calcium, (2) iron (3) vitamins A, B, B<sub>2</sub>, (C) and C and (4) the anti pernicious anemia factor.

Pellagra, beriberi and scurvy usually represent extreme deficiencies and are seldom seen in this country. Minor deficiency states are common. A deficiency in each specific nutritional element results in characteristic signs and symptoms. Certain diseases such as neuritis of pregnancy or alcoholism formerly thought due to some positive toxic agent are now proved due to the lack of specific nutritional elements. Deficiency may be due to a deficient intake of the specific food factors for normal needs, an insufficient supply for abnormal needs as in pregnancy, a defect in absorption or a disturbance in utilization. Almost every tissue of the body may be affected by a deficiency in a food factor.

While not specifically mentioning any roentgenologic features, this review is interesting in view of the knowledge we now have of the dependence of the endocrine glands for proper functioning on an adequate diet and the evident interlacing of these factors in changes in the roentgenographic image of bone.

CHARLES G. SUTHERLAND, M.B. (Tor.)

## DIATHERMY

The Super-high Pressure Lamp. G. J. van der Plaats. Strahlentherapie, 1936, 56, 497-506.

The author describes a new type of quartz mercury vapor lamp which works under a pressure of about one hundred atmospheres at a temperature of 8,600°. Spectral analysis showed that, with increasing pressure the specific mercury lines decrease in intensity and the lamp becomes principally a source of red and infra-red light. The possibilities of its use in medical practice are discussed.

ERNST A. POHLE, M.D., Ph.D.

## THE ESOPHAGUS

Roentgen Therapy of Carcinoma of the Esophagus. Arnold Bernstein. Strahlentherapie, 1936, 56, 366-376.

The author reports four cases of carcinoma of the esophagus that responded—at least temporarily—to roentgen rays. Technique: 200 kv, 6 ma, 50 cm FSD, 0.5 mm Cu + 3.0 mm Al 6-8 fields 480-600 r per field. The exact localization of the area is determined by means of the fluoroscopic screen. In each instance there was a definite decrease in size of the neoplasm and an improvement of the stenosis, lasting for several months. The author recommends, therefore, the use of roentgen rays in suitable cases because further improvement of the technique may increase the efficacy of the method. Eleven roentgenograms are appended showing the appearance of the esophagus before and after treatment.

ERNST A. POHLE, M.D., Ph.D.

## GALL BLADDER, NORMAL AND PATHOLOGIC

The "Double oral" Method for Cholecystography. Lester R. Whitaker. Am Jour Roentgenol and Rad Ther. February, 1936, 35, 200-203.

In comparing all the methods employed in cholecystography, the "double oral" method is recommended. This consists of one full dose of the drug following an ordinary noonday meal and another full dose following a carbohydrate supper. In a questionable result, another carbohydrate meal and another full dose may be given. The simplicity, easy excretion, conformation to physiologic principles and degree of effectiveness are the reasons for the recommendation.

S. M. ATKINS, M.D.

## GASTRO-INTESTINAL TRACT (DIAGNOSIS)

Intestinal Obstruction Due to Amebiasis. Anthony Bassler. Jour Am Med Assn. June 6, 1936, 106, 1965-1968.

*Endamoeba histolytica* is an invading parasite living in and subsisting on the tissues, most often in the maternal found in and beneath the mucous membrane.

gation the accuracy of the method amounted to 95.2 and 92 per cent, respectively, in the two groups mentioned above

ERNST A. POHLER, M.D., Ph.D.

General Body Exposure with Roentgen Rays at Long Distance in Generalized Carcinomatosis. *Ueuen Mitteil Strahlentherapie* 1936, 56, 279-284

The author used general body exposure with roentgen rays in the treatment of patients with advanced and metastasizing carcinoma. Technique: 200 kv, 13 mm Cu, 120 cm FSD, 40 X 40 cm field size, 25-100 r per area and sitting, two hours per sitting. At times two patients were treated simultaneously by increasing the FSD to 2 meters. Most patients received treatment over a period of from two to eight months with an interval between series of from several weeks to two months. This general plan however was modified to suit the requirements of the individual case. The blood picture was checked every 14 days—if the erythrocytes went down to 3,000,000 and the white blood cells to 2,500, it was found that irradiation should be discontinued. Since 1933 a total of 150 patients have been treated with this method. While it is too early to offer definite conclusions the preliminary results have been encouraging even in hopeless cases.

ERNST A. POHLER, M.D., Ph.D.

Roentgen Therapy of Carcinoma of the Cervix with Super high Voltage Apparatus. *Gunsett Strahlentherapie* 1936, 56, 422-436

The author briefly describes the super high voltage unit which has been installed at the Cancer Center in Strassburg. The results of his series of physical measurements are given. A comparison is then made of the skin doses given with the 200 and 520 kv technique in carcinoma of the cervix. If two anterior and two posterior areas were used it required approximately 3,400 r per field or 30 hr and 46 min to administer a dose in the tumor of 3,600 r with 200 kv and 50 cm FSD. The respective figures for 520 kv at 1 meter FSD are about 2,200 r per field and 20 hr and 18 min total treatment time. The considerable drop of the skin surface dose and the decrease in the treatment time as compared with the 200 kv technique are obvious. The ratio between skin and depth dose with the 200 kv technique can however be improved by increasing the FSD to 100 centimeters. The drop in intensity due to increase in distance can be at least partially compensated by an increase in tube current. Future studies will show which of the two methods, super-high voltage or 200 kv radiation with high tube currents is preferable.

ERNST A. POHLER, M.D., Ph.D.

## THE COCCYX

Roentgen Therapy of Coccygodynia. *C. I. Baasstrup Strahlentherapie* 1936, 56, 184-188

The term "coccygodynia" was proposed in 1859 by Simpson and defined as pain in the region of the coccyx. The symptoms consist mainly of pain when sitting

down, difficulty in sitting still and in raising from the chair the os coccyx being tender to pressure. Of 15 cases of this type treated by the author eight were of non-traumatic and seven of traumatic origin. Ten patients were cured by x-ray therapy in two cases only was there a complete failure of treatment. Technique: 300 r, 5 mm Al or 0.5 mm Cu. The method should be given a trial in men and also in women beyond the menopause.

ERNST A. POHLER, M.D., Ph.D.

## CONTRAST MEDIA

Extraneous Shadows Complicating Urography with Special Reference to Radiopaque Pills. *Adolph Hartung and T. J. Wachowski Jour Am Med Assn* Feb 22 1936 106, 596-598

These authors report three cases in which radiopaque pills were visualized and offered difficulty in diagnosis. Reviewing the literature they compiled a list of entities that may simulate renal concretions. These included material in the bowel such as fecal masses, enteroliths (in the bowel or appendix), fruit pits, opaque salts (especially residues of bismuth or barium in diverticula of the colon), pills of ferrous carbonate and capsules containing phenyl salicylate. Gallstones, calcified glands, calcified tuberculous foci in the kidney, calcified tumors in the pancreas or in contiguous structures, calcified areas in the spleen, calcification in a blood clot or surrounding a foreign body (including phleboliths) may simulate renal or ureteral calculi. Fibromas, warts and scars have been mistaken for them. Artefacts present in the film or screen and superimposed shadows of clothing may be confusing.

Ammonium chloride and sodium acid phosphate, the former in enteric coated pills, cast shadows in their experience. They combined 35 pills and tablets in one roentgenogram to demonstrate the comparative densities.

CHARLES G. SUTHERLAND, M.B. (Tor.)

Ventriculography with Colloidal Thorium Dioxide. *Walter Freeman, Herbert H. Schoenfeld and Claude Moore Jour Am Med Assn* Jan 11 1936 106, 96-100

The authors and their colleagues have used colloidal thorium dioxide for ventriculography in about twenty cases over a period of two years. Advantages are that it is freely miscible with the ventricular fluid permitting ready diffusion throughout the cavities. It is also of high specific gravity, tending to reach the dependent points in the ventricular system, outlining the aqueduct and the fourth ventricle.

It is of high radiopacity so that only small quantities are necessary for the satisfactory visualization of the whole system. In cases in which the fluid pathways are free from obstruction it passes readily to the subarachnoid space and is eliminated within four hours from the cranial cavity, at least in amounts detectable by the roentgen ray. Most important of all, the pres-

The etiologic factors were post operative adhesions as the most common inflammatory adhesions, peritoneal veils and constricting membranes (rare), primary and secondary malignancy strangulated hernia volvulus, intussusception and intestinal contents, like gallstones, and other rare conditions

The method of examination varies with the individual case but is always begun with a flat film of the entire abdomen which in itself may lead to a diagnosis. If there is doubt about the loops, a barium enema is given, and if doubt still exists, two or three ounces of barium sulphate mixture is given by mouth and its course followed through the intestinal tract even though the obstruction may be complete

Roentgen findings are the same regardless of the cause. In complete small bowel obstruction there is gaseous dilatation of the proximal intestinal loops, with development of the 'herring bone' or 'ladder' pattern. Examination in the upright position or trans abdominal may show fluid levels in the gas filled pockets of the small intestine. In large bowel obstruction gas also accumulates in the proximal loop but not so characteristically and further investigation is usually necessary. In paralytic ileus the entire intestinal tract contains air, in contradistinction to mechanical occlusion in which no air is present distal to the point of obstruction

The location of the obstruction is difficult, although if the dilated bowel is high it is assumed to be in the jejunum and if low in the ileum. The serrated effect of the valvulae conniventes may be seen in the jejunum. The absence of lines of cleavage and spread of the intestines may indicate accompanying fluid

In partial obstruction, which is extremely difficult to diagnose the harum meal is followed every hour or two until it has completely passed through the small intestine, with the hope of seeing malformed intestine. In the large bowel every method at hand is used if necessary

S M ATKINS, M D

Polypsis of the Colon. Report of a Case. George E W Hardy Jour Am Med Assn March 14 1936 106, 910-913

The author reports a case in a Cuban woman aged 23. Roentgenoscopic and roentgenographic examination suggested polyposis and surgical investigation confirmed this finding. Autopsy revealed a diffuse polyposis of the colon to a point 40 cm from the anus. The lower 12 cm of the ileum was moderately and uniformly thickened

A review of the literature suggested the simplest classification to be that of Erdmann and Morris: the adolescent and the adult type. The adolescent or congenital disseminated type manifests itself in early youth, is characterized by chronic recurring attacks of intestinal hemorrhage and diarrhea and shows a tendency to occur in members of the same family. The adult or acquired type first appears in adult life in association with frank evidences of chronic traumatic

and inflammatory lesions, to which it is evidently secondary. The two types have in common a marked predilection for the large intestine, an evidence of malignancy of more than 40 per cent, and a tendency to chronic intestinal hemorrhage and diarrhea. In the adolescent type the polyps appear in almost countless numbers, are widely disseminated, and show no gross evidence of a causative lesion. In the adult type they occur in limited numbers and extent and almost invariably are associated with gross evidence of trauma, inflammation, or foreign body. Pseudopolyposis is characterized by the formation of polyps arising from islands of mucous membrane isolated in the bases of dysenteric ulcers (Woodward)

Because of the serious danger of malignant transformation, palliative measures such as cecostomy and appendicostomy are not to be considered except in the exceptional case

CHARLES G SUTHERLAND, M B (Tor)

## GENITO-URINARY TRACT (DIAGNOSIS)

Intravenous and Retrograde Urography. A Comparative Study. R E Cumming and G E Chittenden Jour Am Med Assn, Feb 22, 1936, 106, 602-606

Nearly thirty years ago the roentgen ray was made immeasurably valuable in the study of urogenital lesions by the successful practice of pyelography. The work of the cystoscopist was expanded greatly following the regular adoption of pyelographic technique. So, likewise, an added burden was placed on the roentgenologist who was forced to learn much of the intimacies of urology in order to be of the greatest assistance possible in the interpretation of roentgenograms

The development of intravenous urography has again increased the scope of work on the part of both the urologist and the roentgenologist. With the two methods of urography in constant and indiscriminate use, it is more than ever necessary to establish a proper alliance between roentgenologists and clinical urologists

The authors compiled an up to-date estimate of the value of intravenous urography from a questionnaire which was mailed to 350 active physicians. The answers to this are presented in a series of tables which comprehensively answer many of the questions current regarding various phases of the intravenous method

CHARLES G SUTHERLAND, M B (Tor)

The Radiological Findings in Pre-pyloric Lesions. A C Singleton Canadian Med Assn Jour April, 1936, 34, 382-386

The author attempts to clarify the difficult diagnosis of lesions in the prepyloric two-and one-half centimeters of the stomach. Differentiation includes spasm from extra- and intra-gastric causes, involvement in extra-gastric disease by adhesions and extension, annular carcinoma, prepyloric ulcer, and hypertrophic pyloric stenosis of adults. Criteria for differentiation depend on demonstration of spasm, passage of peristal-



of the colon. Usually the pathologic condition noted is moderate thickening of the mucosa with surface ulcerations. In practically all cases antiamebic treatment causes a rapid reduction of the disorder. Cysts may continue in the stools and thus the potential of recurrence of clinical symptomatology is always present. No case should be considered cured without negative stools for cysts for at least six months and normal colon by x-ray examination.

A case report is presented of a male aged 50 years in whom *Endamoeba histolytica* was found in November 1933. In monthly examinations after January 1934 after a negative period of over a year, an occasional histolytica cyst was encountered. In June 1934, treatment was resumed and in September 1934 stool tests showed positive findings. He was not seen for a year after this and seven days after resuming treatment he was operated on for intestinal obstruction and two weeks later the feces were found to be full of amebas. Serial roentgenograms commencing three months after operation showed a marked improvement of the whole colon. The patient was still resistant to antiamebic treatments of all kinds.

CHARLES G. SUTHERLAND, M.B. (Tor.)

Observations on Small Intestinal Physiology in the Presence of Calcified Mesenteric Lymph Nodes. Ross Golden. *Am Jour Roentgenol and Rad Ther* March 1936, 35, 316-323.

Symptoms produced by mesenteric lymphadenitis may vary greatly. In some instances there is merely a dull discomfort in the right lower quadrant while in others the pain is of more violent nature. The mechanism of the pain is not well understood. It may be that there is a mechanical irritation of the nerve fibers in the mesentery or that there is inflammatory irritation of the peritoneum over the node. Apparently a solidly calcified node may be just as capable of causing symptoms as one in which the disease is more active.

The author reports a series of seven patients all of whom had calcified mesenteric lymph nodes which were probably, in all but one individual directly related to the symptoms. Various manifestations of disturbed small bowel physiology were observed. Spasm in the loop of small intestines adjacent to the nodes was noted in four cases and the same number showed delay in passage of the opaque mixture past the site of adenopathy. Two cases showed 9 hour ileal residue and two showed 24-hour ileal residue. Four cases showed delayed gastric emptying and one showed reversed peristalsis of the ileum. These functional disturbances may also contribute to the symptom-complex.

J. E. HABBE, M.D.

Diagnosis and Treatment of Intestinal Obstruction. Richard Goldbahn. *München med Wchnschr* Jan 17, 1936 83, 97-101.

Since the mortality is entirely dependent upon the length of time which elapses before operation earlier diagnosis is imperative and classical signs of ileus should never be awaited as these are late and often never pre-

sent themselves. Physical signs are meager, and no great importance should be attached to constipation as normal bowel movement may occur with obstruction. Diarrhea is reported in a certain percentage of cases of ileus. Vomiting is an important symptom, but one should not wait for the fecal type of vomitus. Hitherto much too little importance has been given to abdominal auscultation for one so skilled can readily differentiate the loud, ringing gurgling sounds of ileus. The early stage of peritonitis gives a similar sound but inasmuch as both conditions are surgical emergencies, their confusion is not a serious matter. When paralytic ileus supervenes all sounds cease.

Great stress is placed upon early roentgenographic examination with the patient in either the erect position, or with projections obtained laterally, in order to note the presence of gas collections with fluid levels. These fluid levels appear very early, and have been observed two hours after the onset of incarcerated hernia. One can usually differentiate the large from the small intestines by the mucous membrane pattern, but when in doubt an opaque enema is indicated. Confusing conditions such as ascites with floating gas filled intestinal coils and gas-containing intraperitoneal abscess must be considered. It is unimportant to distinguish strangulation from obturator ileus.

It is however of great importance to distinguish intestinal obstruction from simulating conditions such as central pneumonia with no physical signs (in which roentgenologic examination of the chest is indicated), cardiac disease with embolic mesenteric occlusion, various colics resulting from the passage of calculi with concomitant abdominal distention, toxic conditions: uremia, diabetic coma, grippe—especially when in epidemic form.

It is difficult and not important to distinguish peritonitis from ileus and administration of morphine is condemned as masking symptoms. The treatment is essentially immediate laparotomy, except in children under one year of age in whom it is well to wait for spontaneous resolving of intussusception or incarcerated hernia. A most complete and instructive discussion of the indications and contra indications for the various surgical procedures is presented.

WILLIAM R. STECHER, M.D.

Intestinal Obstruction. L. R. Sante. *Am Jour Roentgenol and Rad Ther* December 1935 34, 744-753.

This is a review of the roentgen findings in 287 cases of the last five years all of which were checked by either operation or autopsy findings.

The most prominent symptoms were obstinate constipation and vomiting. In complete small bowel obstruction vomiting may be the most prominent symptom, while in large bowel obstinate constipation and vomiting may not develop until much later. Intermittent colicky pains are a feature of acute small bowel obstruction although later after extreme toxemia the pain may disappear. Gaseous distention is also present and visible peristalsis may be seen also.

- 3 Of most importance is localized compression immediately above the symphysis pubis by placing a small rubber ball beneath the compression binder of the Potter-Bucky diaphragm as previously advocated by the writer

During the actual exposure of the films the ball should be removed in order to permit the lower ureters to fill and to eliminate the shadow of the ball. This technic has been used with much satisfaction and often affords such good visualization of the ureters that doubtful shadows in the lower third may be readily identified and such lesions as strictures, kinks and dysfunction of the ureteral musculature may be studied especially if serial films are obtained.

Out of a series of 150 patients the author found that intravenous urography alone sufficed for an accurate diagnosis in 97 of the cases. Of this group the diagnosis was negative in 49. The remainder of the group of 150 cases required subsequent cystoscopy and retrograde pyelography.

An ample discussion of the author's paper is included and should be read by everyone interested in the subject of intravenous urography.

DAVIS H. PARDELL, M.D.

## GYNECOLOGY AND OBSTETRICS

Hysterography as an Aid in the Diagnosis of Abdominal Pregnancy. Report of a Case. J. P. Greenhill. *Jour Am Med Assn*, Feb 22, 1936, 106, 606-608.

The author reports a case in which this method was used to confirm a clinical diagnosis of mature dead fetus outside the uterine cavity. A review of the literature revealed reports of only seven cases in which the injection of iodized oil into the uterine cavity was employed for the purpose of verifying a diagnosis of abdominal pregnancy.

Injection of iodized oil into the uterus under such circumstances is not only a simple and relatively harmless procedure, but presents absolute evidence of the presence of a pregnancy outside the uterine cavity.

When a roentgenogram shows a fetus that has a collapsed skull and/or other evidences of fetal death and there is a suspicion of extra uterine pregnancy, or in cases in which the fetus is dead and repeated attempts to induce labor by mechanical and medicinal means fail to bring about expulsion of the child, hysterography is indicated. If the child is alive and there is some doubt as to the diagnosis, it might be dangerous to inject solutions into the uterus.

CHARLES G. SUTHERLAND, M.B. (Tor.)

Röntgen Therapy in Advanced Carcinoma of the Vagina and the Cervix. F. Baclèsse. *Strahlentherapie*, 1936, 56, 189-190.

The majority of radiologists advocate combined x-ray and radium therapy in carcinoma of the cervix. While the author uses the same method at the Curie Institute in Paris, he states that encouraging results

may be obtained following the use of x-ray therapy alone chiefly if there is vaginal involvement. His analysis is based on 63 cases treated during the period 1922-1930. They were all observed for at least a five-year period. The clinical classification, technic, skin reactions and complications are discussed in detail.

In conclusion, the author states that although the combined roentgen and radium therapy is usually the method of choice, there are some cases which are more suitable for roentgen therapy alone. In his opinion they are those in which cancers grow into the vagina rather than into the parametrium. He obtained 14 per cent five-year cures by applying doses as high as 16,000 r. Since this may lead to late injuries, he proposes to reduce the daily doses in the future as well as to distribute the entire treatment over a period of from six to eight weeks. He also feels that an increase in the tube potential giving better penetration might increase the percentage of cures.

ERNST A. POHLE, M.D., Ph.D.

Discussion on Radiology in Relation to Obstetrics. *Proc Royal Soc Med*, April, 1936, 29, 689-700.

Professor Daniel Dougal recommends radiographic pelvimetry in all primiparae during the early months of pregnancy and stresses the value of radiography in obstetrics. The information obtainable he enumerates as follows:

- 1 Anatomical variations
- 2 Pelvic changes due to pregnancy
- 3 Size and disposition of fetus during pregnancy
- 4 Ossification in fetal skeleton—fetal maturity
- 5 Mechanism of labor, normal and abnormal
- 6 Abnormalities (undue size, faulty attitude, malformation, malposition, malpresentation)
- 7 Placenta previa
- 8 Ectopic pregnancy
- 9 Single or multiple pregnancies
- 10 Determination of size of fetus
- 11 Intra uterine death of fetus
- 12 Accurate pelvic measurements
- 13 Measurements of fetal head
- 14 Disproportion between head and pelvic inlet.

Dr. R. E. Roberts places before the radiologists the following as outstanding obstetrical problems:

- 1 Is the patient pregnant?
- 2 What is the position and presentation of the fetus?
- 3 What is its period of gestation?
- 4 Is there any major or minor pelvic deformity? What are the measurements of the diameters of the pelvic brim and/or outlet?
- 5 Is there any disproportion between the size of the fetal skull and that of the maternal pelvis?
- 6 Is there a multiple pregnancy or a fetal abnormality to account for hydramnios which is present?
- 7 Is the fetus alive or dead?
- 8 Is the pregnancy extra uterine?
- 9 Is the antepartum hemorrhage due to placenta previa?

sis through the deformity, the absence of six-hour residue palpation of a mass in the area of the involvement and whether or not the lesion involves the prepyloric region of the stomach only.

It is interesting to note that the author regards two weeks in bed on a bland diet as being the best antispasmodic in his experience likewise that benign prepyloric ulcers seldom produce a palpable mass in contradistinction to the malignant ulcer. Spasm is infrequently present in the pylorus in malignant ulcers.

Hypertrophic pyloric stenosis may be short, or as much as three centimeters in length. The lumen of the contracted pylorus is central, symmetrical and involves an equal length of greater and lesser curvatures and may indent the base of the duodenal caput. Since this lesion does not respond to antispasmodic measures, and since the age incidence is from 14 to 60 years the condition is very difficult to differentiate from annular carcinoma. Serial examinations are of great benefit here as in other radiologic studies.

W. H. GILLISTINI, M.D.

The Bladder Function in Spinal Injury. K. H. Watkins. *British Jour. Surg.* April 1936 23, 734-759.

The author concludes in his study of the cases recorded that active sacral spinal segments are of fundamental importance to bladder function. The influence of these segments below a complete transverse lesion is such as to promote a perfect reflex micturition which differs essentially from the normal in its entire independence of voluntary control.

The behavior of the bladder in lesions of the conus and cauda equina is evidence of a limited degree of function mediated by the peripheral nerve ganglia. It has been shown above, however, that this function is not of itself efficient in evacuating urine from the bladder for even when the internal sphincter is widely relaxed and the detrusor in contraction there may be no escape of fluid from the bladder. It can only be concluded therefore that its peripheral innervation alone determines a very ineffective bladder function.

It is without doubt the existence of a considerable mechanical resistance in the region of the triangular ligament which deprives this function of the bladder of most of its effect but it is in virtue of this resistance combined with the patient's ability to expel urine by straining with his abdominal muscles, which provides him with the means of living in relative comfort. This patient is, therefore, in much better circumstances than the patient with a transverse cord lesion who though he has a very perfect reflex micturition, is not able to control it. Several interesting graphs and roentgenograms accompany the article.

DAVIS H. PARDOLL, M.D.

The Limitations of Intravenous Urography. Thomas D. Moore. *South Med. Jour.* March 1936 29, 242-248.

In the author's article the following factors are cited as possibilities for poor or absent visualization:

1 Temporary or reflex inhibition of function such

as commonly occurs in the presence of a ureteral calculus,

2 Incomplete filling rendering proper interpretation impossible,

3 Hypersecretion and hypermotility with little or no medium retained in the renal area,

4 Non-calculus obstruction at the renal outlet or along the course of the ureter, if of short duration, normal function will soon follow elimination of the obstruction.

5 Temporary impairment of function due to nephritis and occasionally to toxic states,

6 True absence of function such as may be caused by advanced renal tuberculosis, extensive neoplasm or pyonephrosis.

Errors in diagnosis may be explained in several ways as follows:

1 Inexperience in the interpretation of pyelograms,

2 Unsatisfactory pyelograms for proper interpretation,

3 Reluctance to request more complete data by employing the cystoscope with or without retrograde pyelography.

In the writer's experience he has found intravenous urography to be most helpful and dependable in the following conditions:

1 In the identification of doubtful shadows in the region of the upper urinary tract,

2 In the demonstration of renal and ureteral anomalies.

3 In proving or disproving the existence of stasis.

4 In the course of differential diagnosis the observation that both kidneys are of normal outline and function often will render a cystoscopic examination unnecessary.

5 Under circumstances in which instrumentation is inadvisable such as acute specific urethritis, senility, patients in poor general condition and in infants or small children.

In the presence of gross hematuria or pyuria in the majority of cases the information afforded by intravenous urography is inadequate for the determination of the cause or source of the blood or pus. The detection of renal tuberculosis in its early stage or the exclusion of this disease in the opposite kidney requires data other than that afforded by intravenous urography. The same may be said of the diagnosis of early neoplasms which may cause slight deformities often not discernible in the urogram. Neither can the method be relied upon for the recognition of polycystic disease with its attendant poor function.

Good visualization of the structure comprising the upper urinary tract will be greatly enhanced if due consideration is given technique. The following factors have been found of great importance:

1 The withholding of fluids for at least twelve hours prior to the examination, which induces a greater concentration of the media and therefore denser shadows.

2 A preliminary laxative for the elimination of intestinal markings.

# RADIOLOGY

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## HEART MEASUREMENTS<sup>1</sup>

By ELIZABETH NEWCOMER, M D , and NATHAN B NEWCOMER, M D  
*Denver, Colorado*

LEADING heart authorities agree that general enlargement of the heart is the most reliable proof of heart disease

Bedford and Treadgold (4) state "It is not going too far to say that enlargement of the heart is the most unequivocal single sign of heart disease which is generally applicable"

Eyster (11, 12) states "The differentiation of the enlarged heart from the heart of normal size is the most important single factor in determining the presence or absence of organic heart disease With the exception of mitral stenosis and atrophic myocarditis, all but the rarest types of organic heart disease lead to hypertrophy of the ventricles Except in rare instances, the left ventricle is most affected in the types with which the physician has to deal This chamber is most affected in double mitral disease, in aortic disease in adherent pericardium, in arterial hypertension, and in myocardial degeneration associated with syphilitic or other types of aortitis and arterial injury"

Christian (5) quotes Cabot as saying "Seventy-seven per cent of all heart disease is due to simple hypertrophy and dilatation of the heart (or hypertensive cardiovascular disease) without valve lesions"

<sup>1</sup> Read before the Midsummer Radiological Conference in the Rocky Mountains Aug 5, 6, 7 1936, Denver Colorado Sponsored by the Denver Radiological Club

Christian further states "At the Peter Bent Brigham Hospital they form 61.1 per cent of the patients admitted to the wards suffering from chronic heart disease

"At any rate in a clinical sense, it does seem true that any heart, demonstrably enlarged, is to be regarded as a damaged organ, which before very long will give evidence of inefficiency"

Christian defines chronic myocardial disease as, "that form of cardiac failure in which valves and pericardium are normal in appearance Usually there is hypertrophy and dilatation of the heart In a large percentage of the cases the heart muscle shows no demonstrable lesion beyond hypertrophy, in a small percentage there is fibrous myocarditis"

Sir James Mackenzie (33) states "Dropsy of cardiac origin never occurred without dilatation of the heart"

Sir Thomas Lewis (31) states "The reasons why enlargement affects prognosis are that enlarged hearts are far more prone than are small ones abruptly to display signs of failure, that they are more apt to suffer from thrombotic accidents, coronary or endocardial, the latter leading to embolism, and that they tend more to acquire serious disorders of beating"

Willus and Smith (47), in reporting autopsies on a series of rheumatic cases, state "The greatest average cardiac weight

He further discusses most of the problems under the following heads

- 1 Period of gestation
- 2 Pelvimetry and cephalometry
- 3 Hydramnios
- 4 Placenta previa

The following authors participated in the discussion

Dr Norman Reece stated that the biparietal diameter of the fetal head can be measured with reasonable accuracy by x rays and this measurement gives useful information as to fetal maturity

Dr Cecil Bull utilizes the sitting recumbent and lateral positions for measurements measuring the diameters which appear in the three positions and uses the tables of Scrimmon and Calkins to determine fetal maturity

Dr W G Mackay utilized amniography on 66 occasions in suitable cases, and in 90 per cent of them he was able to diagnose correctly the location of the placenta. This procedure has limited practical applications which are discussed by the author. In the roentgenogram the placenta is recognized by (1) an uneven surface and (2) thickness

Dr A Durward conducted an investigation of pelvimetry and encephalometry and considers the former more important

Dr Rohan Williams made a strong plea for a compilation of all information with post natal pelvimetry in all cases in which the obstetrician encountered some mechanical obstetric difficulty

Dr M H June attained some success in demon-

strating the fetus in early pregnancy, 12 weeks' gestation with the following method patient prone tube tilted so that the rays (postero-anterior) are perpendicular to the pelvic outlet

HENRY K. TAYLOR M D

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Roentgenologic Diagnosis of Placenta Previa. W H Ude and J A Urner. *Am Jour Obst and Gynec.* May, 1935, 29, 667-679 (Reprinted by permission from *British Med Jour* Aug 24, 1935 p 33 of *Epitome of Current Medical Literature*)

Thirty five cases are reported, together with the routine technic evolved and on which the authors lay stress. They point out that, as treatment frequently has to be by Cesarean section there are great advantages in a method of diagnosis which avoids digital examination and shows the exact position of the placenta. Exposure must be rapid, directly antero-posterior, on a film large enough to show the whole fetus, and with a contrast material (40 cc of 12.5 per cent sodium iodide) to show up the bladder wall. Lateral roentgenograms are useful in determining the position of a placenta above the lower uterine segment. Normally the outline of the fetal head impinges upon that of the bladder. Placenta previa distorts this shadow, and with experience interpretation of the differences becomes possible, given a vertex presentation. Blood clot from a premature separation of the placenta needs roentgenograms at 24 hour intervals for differentiation

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entirely of the right auricle. Only a narrow strip of the left ventricle is seen on the left border and above this only a minute

the heart is called the *length*, or *long diameter*, or *oblique diameter* of the heart.

3 A horizontal line is drawn from the

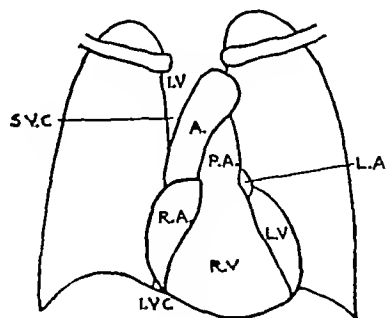


Fig 3 Normal heart, anteroposterior view (East and Bain)

- I V —innominate vein
- S V C —superior vena cava
- R A —right auricle
- I V C —inferior vena cava and right hepatic vein
- R V —right ventricle.
- A —aorta
- P A —pulmonary artery
- L A —left auricle
- L V —left ventricle

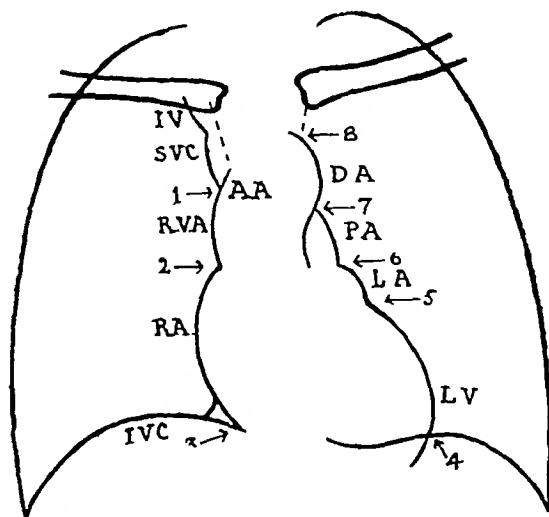


Fig 4 Normal anteroposterior view of the heart (near view) (From Köhler)

1-8—indicate the notches between the various arches

- R A —right auricle
- R V A —right vascular arch
- A A —ascending aorta
- L V —left ventricle
- L A —left auricle
- P A —pulmonary artery
- D A —descending aorta
- I V —innominate vein
- S V C —superior vena cava
- I V C —inferior vena cava
- 3 and 4—The cardiophrenic angles

portion of the left auricle is exposed to view. Above the base of the heart in the midline, the aorta is seen on the right and the pulmonary artery on the left. The junction of the right auricle and right ventricle is at the junction of the heart with the diaphragm.

The contour of the right side of the silhouette of the heart and vessels is made up of two main arches or convexities. The upper arch consists of the first part of the aorta and the superior vena cava, the lower and larger arch consists of the right auricle. On the left side, there are four arches, from above downward, as follows: (1) posterior portion of the aorta, (2) pulmonary artery, (3) left auricle, (4) left ventricle.

In measuring the silhouette of the heart, the following lines are generally drawn:

1 A vertical line through the spinous processes or midway between the heads of the clavicles is called the *midline*.

2 An oblique line drawn from the junction of the great vessels and the right auricle on the right border to the apex of

the farthest point on the right to the midline, another horizontal line is drawn from the farthest point on the left to the midline, and the sum of these two lines is called the *transverse diameter*. This is not a true diameter of the heart and varies with the angle of inclination of the heart. It does not pass through the same areas at even approximately the same angles in different types of hearts, consequently, in using it for comparison you are comparing diameters of entirely different structures. This diameter should be discarded.

4 A perpendicular line is drawn from the junction of the left auricle and left ventricle on the left border of the heart to the oblique diameter. A second perpendicular line is drawn from the junction of the right side of the heart and diaphragm,

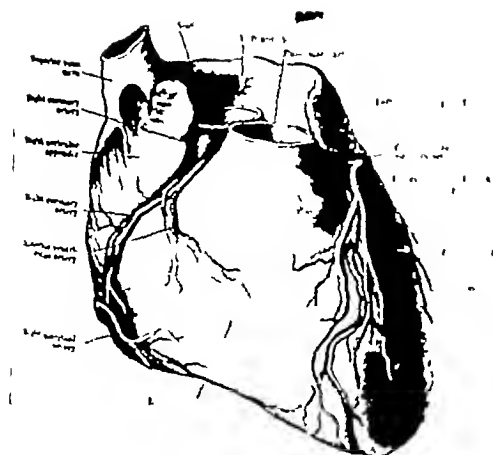


Fig 1 The antero superior surface of the heart  
(Cunningham's Anatomy)

occurred in cases of aortic stenosis. In order of cardiac weight, other lesions occurred in the following sequence: aortic insufficiency, multiple valvular lesions, mitral stenosis and insufficiency, and pure mitral insufficiency."

It is also well to bear in mind that individuals having small vertical hearts, the asthenic type, are predisposed to neuro-circulatory asthenia.

Fluoroscopy, orthodiagraphy, and teleroentgenography are the commonly accepted roentgenologic methods of examining the heart. Each has distinct advantages and all should be used. The two latter are especially adapted to actual heart measurement.

In orthodiagraphy, an outline of the heart is drawn upon a sheet of paper or upon a glass under the fluoroscope by tracing with a small beam of x-ray, giving it a more accurate outline and with less distortion. The apex of the heart and the junction of the left auricle and left ventricle are more accurately located. It requires considerable skill and practice to attain accuracy; there is considerable variation in the tracings of the same individual by the same observers at different times, and often a marked difference when taken by different observers.

Teleroentgenography eliminates the personal equation and gives a permanent

record which can be accurately reproduced. If the film is taken at 6 or 7 feet (2 meters), the distortion is not great. However, by

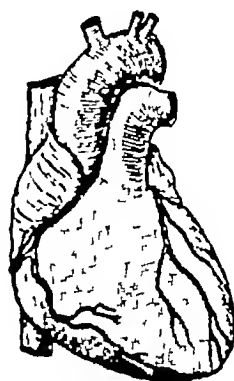


Fig 2 Heart in frontal position  
(Vaquez and Bordet)

this method it is difficult to determine the exact location of the apex and the junction of the left auricle and left ventricle on the left border of the heart.

Measurements based upon the two methods are not interchangeable; measurements taken in the erect, sitting, or reclining position by either method are not interchangeable.

It would be quite desirable to determine the exact size of the heart and its various muscular divisions, but insurmountable difficulties prevent it.

The postero-anterior silhouette and the orthodiagraphic tracing of the heart in this position can be fairly accurately measured. Oblique and lateral views, because of distortion, cannot be accurately measured. Hearts having the same area may vary in volume because of different depths.

The anatomic location of the chambers of the heart does not correspond with the silhouette.

An examination of the heart in the anteroposterior position shows the arrangement of the visible portions to be as follows. The right ventricle comprises the major portion of the anterior surface, its lower border lying on the diaphragm. The right border of the heart is composed almost

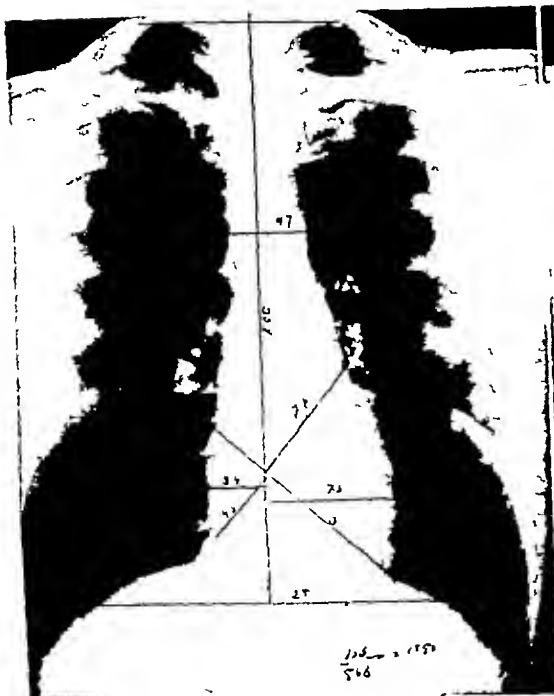


Fig 7 Asthenic type



Fig 8 Medium type

forms rather a small angle with the horizontal plane. The ventral mark corresponds always to the right ventricular border, the dorsal mark always to the left ventricular border."

Roesler gives the anteroposterior diameter as 8.7 cm for men and 7.8 cm for women, maximum for men, 10.7, minimum, 6.7, maximum for women, 9.6, minimum, 6.3 cm. He also gives the average anteroposterior diameter as 73 per cent of the average transverse diameter and 66.3 per cent of the average oblique or long diameter.

Quoting still further from Roesler: "The heart volume would be the area of the sagittal orthodiagram times the greatest depth, times 0.63 or K (Rohrer's constant)."

"The constant K depends upon the angulation of the main axis of the heart and the general shape of the heart. Rohrer chose a constant of 0.63 as being in between the paraboloid and spheroid."

The cardiothoracic ratio is the ratio of the transverse diameter of the heart to the width of the lung-field at its greatest

diameter. Groedel, according to East and Bain, found this ratio to be 1.192. Hammer allowed a variation of 1.170 to 2.20 as the limits of normal. This ratio is inaccurate unless it is corrected for the angle of inclination, as the transverse diameter varies with this angle, hence it is gradually being discarded. However, many investigators, particularly the earlier ones, attach a great deal of importance to it.

Bainton states: "It is rather surprising that the cardiothoracic ratio which is so universally employed as a guide in judging the size of the heart should prove to be the poorest standard of all those considered."

Roesler states: "The cardiothoracic ratio should be considered unsatisfactory in determining normal heart size."

Efforts have been made to measure the different chambers of the heart. The following description is taken from Levene and Reid: If the longitudinal diameter is intersected by a line joining the cardiophrenic angle on the right with the auriculo-ventricular junction on the left, the heart shadow is divided into two areas—the



which is the junction of the right auricle and right ventricle, to the oblique or long diameter. The sum of these two lines is the

position of the heart in the chest, quite markedly in the asthenic, medium, and sthenic types and, consequently, hearts

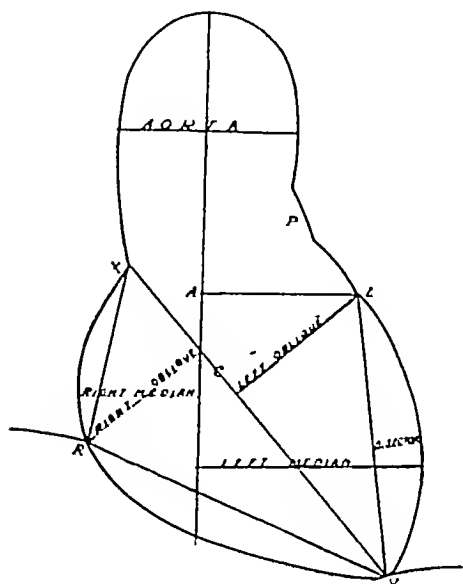


Fig 5

- L A —left auricle
  - L V —left ventricle.
  - R V —right ventricle
  - R X —right auricle
  - C X —C V equals index of auricular ventricular ratio, right median plus left median equals transverse
  - V X —length
  - P —pulmonary artery
- (Levene and Reid in *Am Heart Jour*)

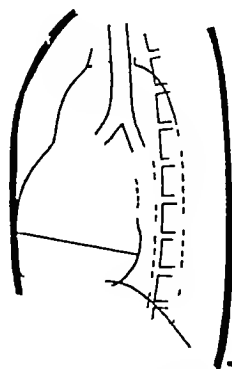


Fig 6 Schematic drawing of the roentgenologic appearance of the heart and chest as seen in the left lateral view. The diameter of the depth of the heart ( $H_D$ ) is indicated. It connects the left ventricular contour, posteriorly, with the inner contour of the sternum, anteriorly just below where the sternal shadow fuses with the right ventricular contour of the heart ( $H$ ). Roesler, *Am Jour Roentgenology and Rad Ther*

broad diameter of the heart, which is a fairly accurate and reliable anatomical measurement of the heart at the junction of the auricles and ventricles and should be used for comparison instead of the transverse diameter.

The angle of inclination is determined by a horizontal line drawn from the apical end of the oblique or long diameter to the midline. Roesler (39, 40) states "The average angle is from 43 to 45 degrees. Hearts with an average angle of from 52 to 55 degrees (or greater) are vertical hearts, those with an average of from 32 to 35 degrees are horizontal or transverse hearts.  $T$  (transverse diameter) is usually in a reverse ratio to this angle. Formulas in which  $T$  is used increase in reliability when the value of the angle is also introduced."

The angle of inclination varies with the

should be classified according to these types.

The area of the heart silhouette is determined by plotting it on cross-section paper or by planimetric determination. Either method requires that the curves at the upper and lower ends be completed by continuing the approximate curve of the adjacent borders of the heart, and consequently is subject to a slight error.

The anteroposterior diameter of the heart (depth) is described by Roesler as follows: "Tangents are drawn to the most ventral and most dorsal point of the heart silhouette as seen in the lateral position. The dorsal point is always easily determined. The ventral point is more cephalic and is just below the plane where the heart shadow fuses with the sternal shadow. The line between these two marks is drawn. It

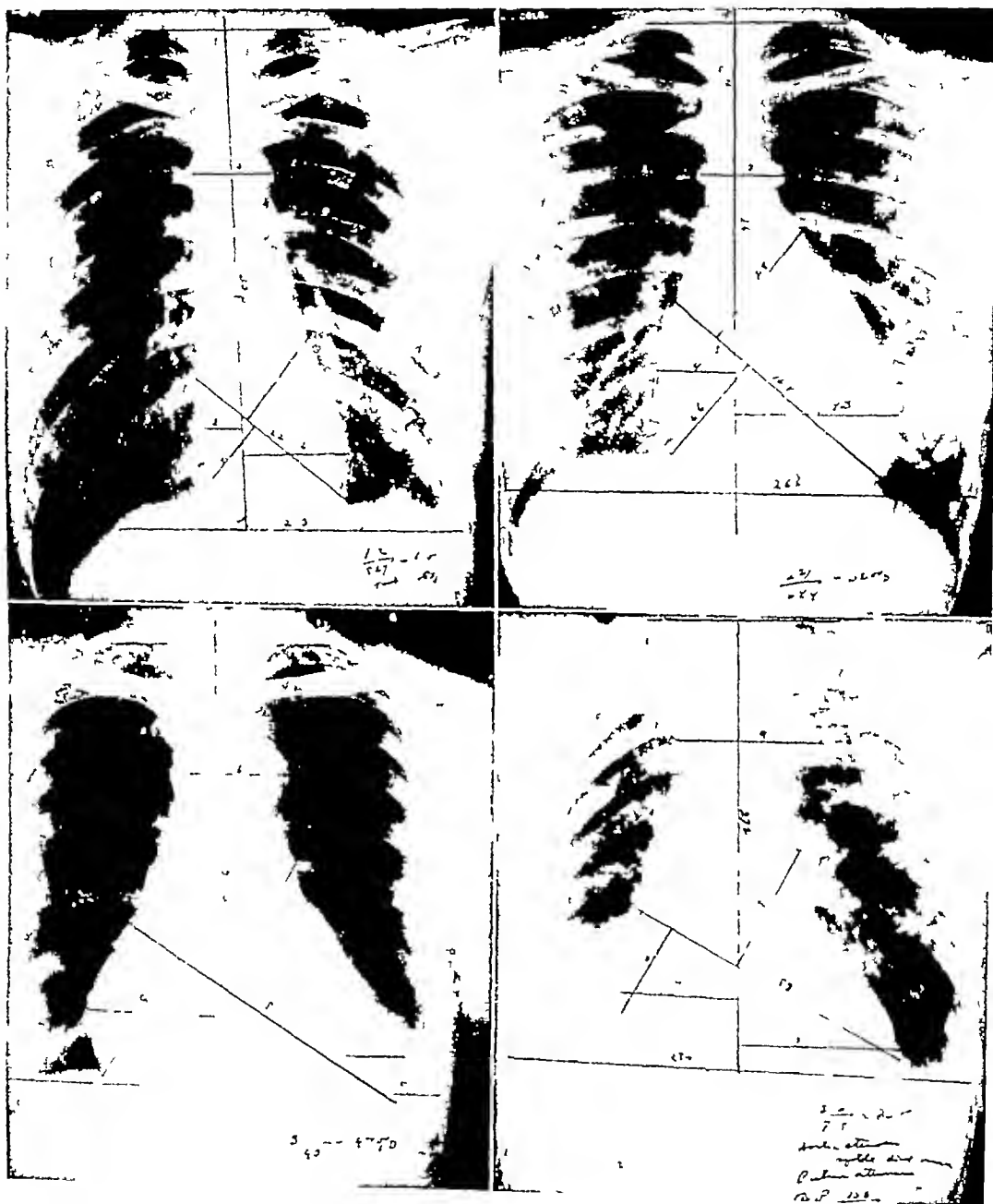


Fig 10 (upper left) Drop heart Exaggerated asthmatic type

Fig 11 (upper right) Enlarged heart due to mitral disease

Fig 12 (lower left) Enlarged heart Auricular fibrillation

Fig 13 (lower right) Cardiac dilatation Pleural effusion  
aortic valve Pulsus alternans

$$\frac{\text{Rectangle of the heart}}{\text{Rectangle of lung-field}} = 16 \text{ per cent}$$

$$\frac{\text{Rectangle of the heart}}{\text{Rectangle of lung field}} = 32 \text{ per cent}$$

$$\frac{\text{Rectangle of the heart}}{\text{Rectangle of lung-field}} = 47 \text{ per cent}$$

Blood pressure 170/100  
Systolic and diastolic murmurs at aortic

$$\frac{\text{Rectangle of the heart}}{\text{Rectangle of lung field}} = 32 \text{ per cent}$$

auricular area above the line and the ventricular area below it. The line joining the cardiophrenic angle on the right with

The bisector, a perpendicular from the point of greatest bulge of the border of the left ventricle to the line measuring its



Fig 9 Sthenic type

the junction of the great vessels and the auricle shows the development of the right auricle. The line joining the cardiophrenic angle on the right to the apical end of the longitudinal diameter shows the development of the right ventricle. The line joining the junction of the left auricle and left ventricle on the left border to the apical end of the longitudinal diameter, shows the development of the left ventricle. A perpendicular line from the junction of the left auricle and left ventricle on the left to the median line indicates the development of the left auricle.

chamber, shows the degree of development of the left ventricular myocardium.

These lines are not true measurements of the anatomical chambers of the heart but are the measurements of the visible portions of these chambers on the heart silhouette.

In order to determine hypertrophy of the heart, it is necessary to determine the size of the normal heart. Numerous tables have been made by different investigators, giving average measurements and upper and lower limits of the area and of the different diameters of the heart. These

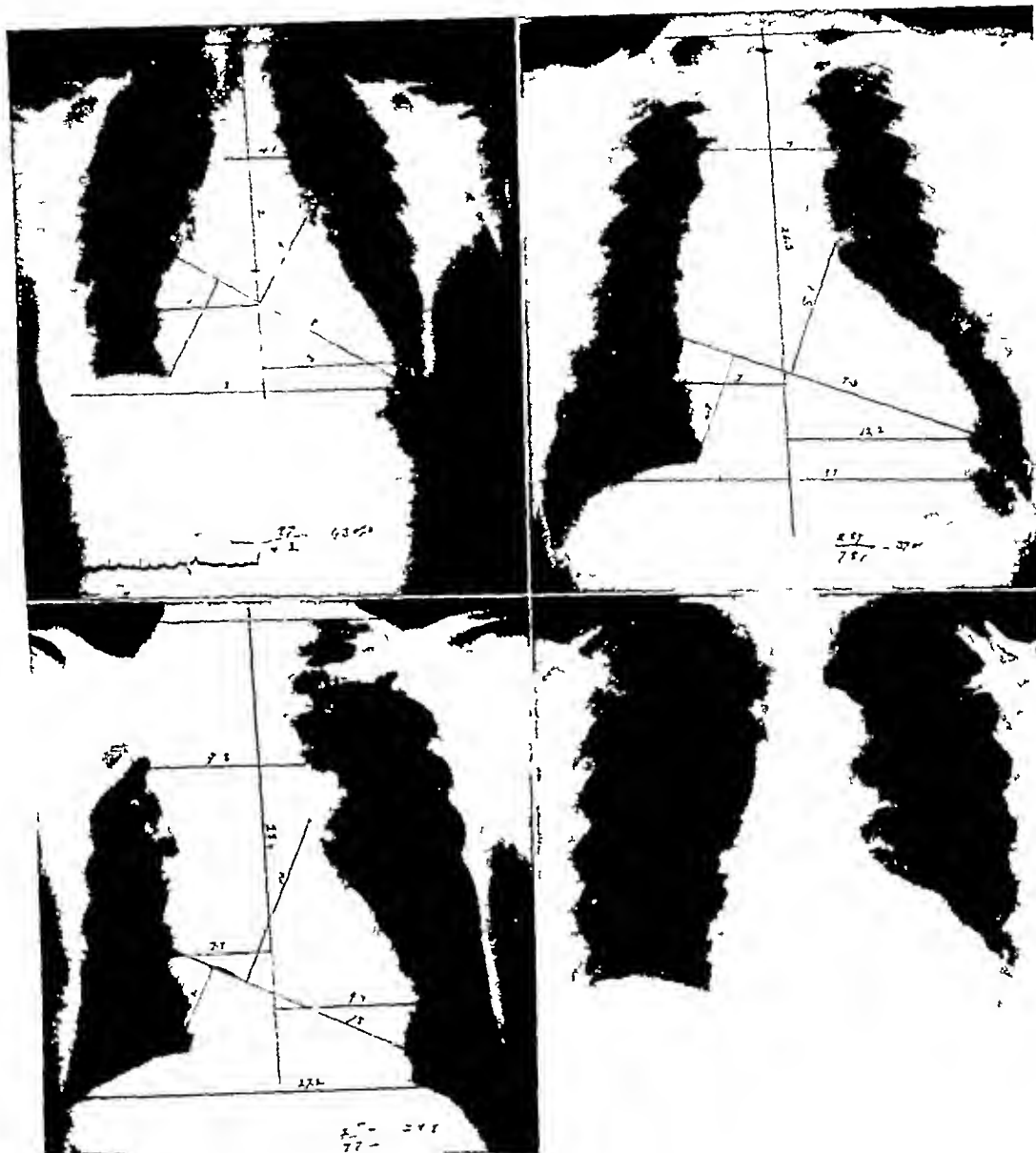


Fig 14 (upper left) Myocarditis  $\frac{\text{Rectangle of the heart}}{\text{Rectangle of lung-field}} = 43 \text{ per cent.}$

Fig 15 (upper right) Aortic valvular disease  $\frac{\text{Rectangle of the heart}}{\text{Rectangle of lung field}} = 37 \text{ per cent}$  Systolic and diastolic murmurs over aortic valves Corrigan's pulse Note enlargement of the great vessels

Fig 16 (lower left) Enlargement of the heart associated with chronic tuberculosis of both lungs  $\frac{\text{Rectangle of the heart}}{\text{Rectangle of lung field}} = 40 \text{ per cent}$

Fig 17 (lower right) Shows an aneurysm of the aorta, outlined by a barium meal in the esophagus Wassermann plus 4

verse diameters He calls it the "cardiac rectangle"

Host uses the same cardiac rectangle as Moritz He states that the orthodiagram is not supplemented by construction of

upper and lower borders but a rectangular figure is constructed, the base of it being formed by the longitudinal diameter of the heart and the height by the width of the heart Comparative measurements show

measurements vary with weight, height, age, sex, angle of inclination (habitus), depth of the heart, etc. Different investigators do not attach the same importance to these different factors.

Several investigators have produced estimation formulas to determine whether or not a given case is within the range of normal and tables have been compiled from these formulas. Probably the most commonly accepted formula is that of Hodges and Eyster. Estimation formulas are an attempt to obtain correction factors for heart size somewhat as Harris and Benedict have for basal metabolism.

Eyster states "It has been found that the size of the heart in the normal subject depends in part at least upon three factors—height or stature, weight, and age—and attempts have been made to develop a prediction formula based on these three factors." He emphasizes the value of the area of the frontal plane of the heart and the greatest transverse diameter.

Bedford and Treadgold state "We have tested Eyster's tables on our series of healthy subjects and they have given as successful a prediction of transverse diameter as we believe it is possible to make."

*Predicted Transverse Diameter by Hodges and Eyster's Formula*—They state that this formula or equation can be translated as follows "The probable normal cardiac transverse diameter of any male subject can be most accurately estimated by adding the products of 0.1094 times A, 0.8179 times W, subtracting from this sum the product of 0.1941 times height, and adding to the remainder the fixed figures of 95.8625."

They state further "As a matter of fact, the efficiency of this formula is 19 per cent, which means that it is 19 per cent more efficient than assuming an average for all cases."

Hodges and Eyster give the formula for estimating the heart area as follows "Predicted heart area in sq. cm. is equal to the measurement of age in years multiplied by the factor 0.0204, plus the measurement of stature in cm., multiplied by the

factor 0.8668, plus the measurement of weight in kg., multiplied by the factor 0.337, minus the constant 63.8049."

Roesler gives other estimation formulas, and discusses in detail the various correlations covering (1) Correlation between figures of cardiac silhouette, volume, and angulation, (2) Correlation of figures of cardiac silhouette and volume with certain body measurements, (3) Similar correlation figures for the lateral view.

Roesler states "The only correct determination of heart size consists in the actual volumetric reconstruction. None of the formulas devised for computation of the heart volume guarantees a sufficiently small error. And only those can give approximately satisfactory results which consider three dimensions of the cardiac shadow."

Efforts have been made by various investigators to correlate the size of the heart with the transverse diameter of the chest, the height of the body, the body weight, the surface of the body, etc., and Lannec and Cunningham compare the size of the heart to the size of the fist.

A method for clinical purposes must be simple and accurate and reproducible by different observers. There is a striking similarity in the shape of the silhouette of the heart and the lung-fields. If tracings of the heart silhouette are placed over the lung-field, with the base of the heart on the diaphragm and the apex pointed toward the apices of the lung-field, this becomes more noticeable. Similar figures can be compared by comparing their area or by comparing the product of the base by the altitude. The measurement of the broad diameter of the heart is less variable than the transverse diameter.

Because of the difficulty in accurately completing the upper and lower borders of the heart, which is necessary in determining the area of the heart silhouette, by either the planimetric method or the cross-section method, several investigators use the cardiac rectangle method.

Moritz states that the size of the heart can be figured out also from a rectangular figure formed by the longitudinal and trans-

lung rectangle as  $\frac{\text{heart rectangle}}{\text{lung rectangle}}$  reduced to a percentage basis, and have compiled a preliminary table in percentages for the asthenic, medium, and sthenic habitus, and urge that each heart should be compared to its type and not to the average for all types -

This method eliminates errors due to the personal equation as in the orthodiagraphic method, the hypothecation of the upper and lower borders of the heart in determining the area of the heart, and the use of the transverse diameter of the heart, which is the least dependable measurement we have. It gives one a permanent record which can be duplicated on the same person or by different operators

306 Republic Building

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that the surface of such a rectangle corresponds to the actual surface

Both Moritz and Host compare the area of the cardiac rectangle (using the transverse diameter) with the area of a rectangle formed by the largest transverse diameter of the thorax and the body height

Roesler states "There is a high correlation between length times the breadth and area (ratio equals 0.85), and it is, therefore, justifiable to use the length times breadth product (heart rectangle) instead of area." He uses the broad diameter in estimating the heart rectangle instead of the transverse diameter. This avoids the errors inherent in all transverse diameter measurements

Consequently, in the method we advocate, the rectangle of the heart is obtained by multiplying the broad diameter of the heart by the long diameter. Instead of comparing the area of the cardiac rectangle to the area of the rectangle resulting from multiplying the width of the chest by the body height, as Moritz and Host advocate, we compare it to the rectangle of the lung-field

To obtain the rectangle of the lung-field, a line is drawn at the base of the lung-field through the upper border of the left leaf of the diaphragm. Another longitudinal line is drawn tangent to the apices of the lung-field. A vertical line is drawn through the spinous processes or the midpoint between the heads of the clavicles intersecting the two horizontal lines. This coincides with the median diameter of the heart. The area of the rectangle of the lung-field may be arrived at by multiplying the length by the width

For several years we have been interested in studying the ratio of the heart rectangle to that of the lung. We divided the heart rectangle by the lung rectangle and reduced it to a percentage basis

We classified all hearts into asthenic, medium, and sthenic types and obtained the following results in normal cases

Average of asthenic types—20 per cent—49 cases

Average of medium types—22 per cent—64 cases

Average of sthenic types—26 per cent—77 cases

Average of all types—23 per cent

We believe any heart going above 28 per cent is enlarged. The average for 53 cases going above 28 per cent was 35 per cent. We believe each heart should be compared with the average of its type and not with the average for all types

The above figures were obtained in routine office work, including insurance examinations. The films were taken at six feet distance and one second time, at full inspiration. In drawing the line at the base of the lung-field, an effort was made to make allowance for the dome of the diaphragm in order to obtain the average depth of the lung-field. This is a mistake, as it allows too much chance of error as the result of the personal element. We believe more accurate tables can be compiled by drawing this line horizontally through the vault of the left leaf of the diaphragm. The film should be taken at full inspiration in order to more clearly outline the apex of the heart. Full inspiration may alter the transverse diameter of the heart considerably but has little effect on the broad diameter. This method compares the areas of two vital organs of the body, both of which are influenced by body build and body weight and have closely related functions in the body economy and vital activities. It eliminates the personal equation entering into the orthodiagraphic method and avoids any personal errors on the part of the examiner. The transverse diameter, which is the least reliable heart measurement, does not enter into it

We wish to emphasize again the fact that each heart must be compared with its type—asthenic, medium, and sthenic

#### CONCLUSION

As a simple clinical method, we are advocating a teleroentgenographic method of comparing the heart rectangle to the

# PNEUMORADIOGRAPHY OF THE KNEE

A NEWER TECHNIC DEMONSTRATING ITS VALUE IN THE DIAGNOSIS OF SEMILUNAR  
CARTILAGE INJURY

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THE futility of attempted diagnosis of lesions of soft parts lying within the knee joint has been reiterated too frequently to warrant further repetition. Narrowing or widening of the joint space on the impaired side has been frequently shown to be of no consistent diagnostic significance. The use of a contrast me-

dic Since 1920 many papers have been published demonstrating the diagnostic possibilities of pneumoradiography, particularly in meniscal lesions. In addition to air-filtered and atmospheric-oxygen, carbon dioxide, and many solutions opaque to x-rays have been used. The use of lipiodol, iopax, abrodil, perabrodil, tetra-

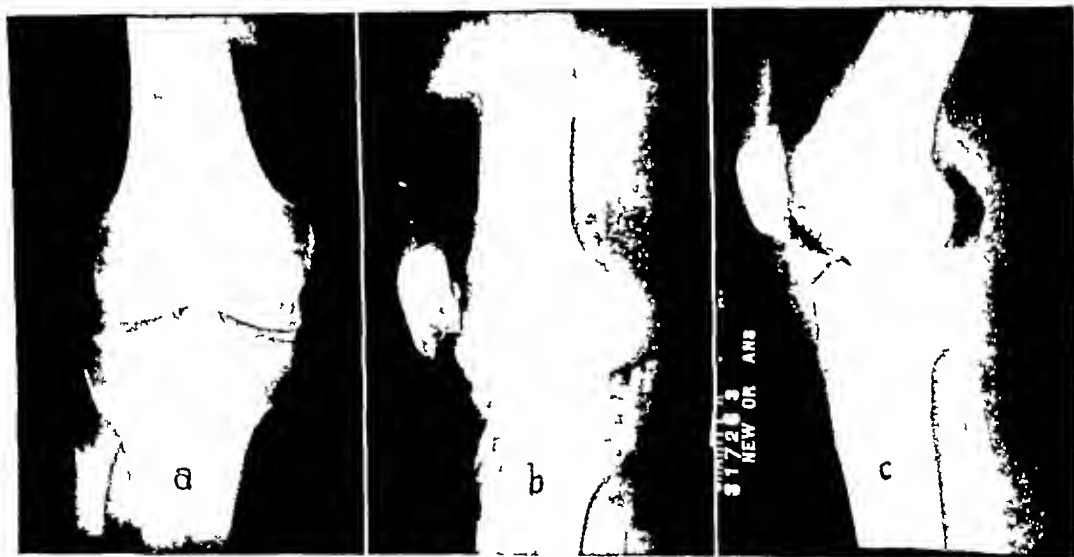


Fig 1 (a) Anteroposterior airgram of the right knee showing calcified medial and lateral menisci. The position of these cartilages should be compared with Figure 3

(b) Lateromedial airgram of the same knee showing the calcified medial meniscus intact anteriorly and posteriorly

(c) Mediolateral airgram of the same knee showing the calcified lateral meniscus intact anteriorly and posteriorly

dium injected into the knee joint in order to emphasize the soft tissue shadows was apparently first performed by Werndorf and Robinson (30), in 1905, using air as the medium. Hoffa (13) recognized the possibilities of the method and commented upon it in 1905 and 1906. Martina (20), Querin (25), Grashey (11), and Weil and Louseleur (29) were cognizant of the tech-

nique. Iodo-ortho-sulphobenzoic acid and many other similar fluids has been reported.

Pneumarthrosis has its opponents as well as proponents. Schoedel (27) lists as possible complications persistent synovitis, gas emboli, and sudden death. A rather thorough search of the literature on this subject has, to date, failed to reveal a case report of any of the above listed



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noticeable lack of correlation in "football knees" between the severity of trauma, the extent of semilunar cartilage damage, and

clinical, roentgenographic, and operative findings could be correlated. These cases have been of particular interest, though the



Fig 5

Fig 6

Fig 5 Normal mediolateral view of the same knee as shown in Figure 3. The anterior attachment (arrows No 1) and the posterior extremity (arrows No 2) of the lateral semilunar cartilage are outlined.

Fig 6 Anteroposterior view of the right knee of a football player with an unstable joint. No locking was noted. The medial semilunar cartilage shadow is thinned. The upper limit is outlined by the arrows. For comparison, note the clear lateral semilunar cartilage shadow.

the clinical findings. The classical syndrome of a severe internal rotation injury of the knee, with the foot fixed, followed by joint instability, a movable tumor, noted subjectively or objectively, pain, and locking was characteristically absent at the onset. Following examination, the usual clinical diagnosis was that of a knee sprain. Only when the disability became chronic and the player was incapacitated for further competition did the true nature of the hidden damage become evident. As one of us (H. T. S.) has been consulting orthopedic surgeon for two of the larger university teams, we have seen, within the past two years or more, a relatively large number of "football knees" in which the

actual number of pneumarthroses (about one hundred) is much greater.

The amount and tension of the air injected in our first few cases was variable, and it soon became apparent that the shadows cast on the x-ray films varied as well. The desirability of uniform plates is evident, therefore, it occurred to us that standardized air pressure would give constant shadows. Porter and Rucker (24), and Berg (2) seem to have been the first to employ a sphygmomanometer to measure the air pressure introduced into a joint, this was, however, for joint inflation in the treatment of joint inflammations, and not for diagnostic purposes. The former used a tension of 25 mm Hg, while the

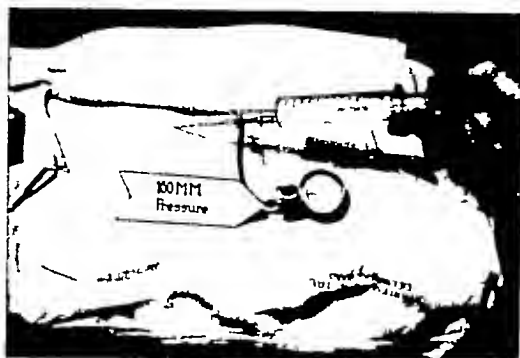


Fig 2 The apparatus consists of a large syringe a spinal manometer needle (B D No 3025) with a two way cock and a sphygmomanometer. For consistent results the pressure should be 100 mm Hg.

ing, and Oberholzer (23) reports over 1,200 cases from Bircher's clinic with no complications of any sort.

Almost as many different technics have been advanced as there are authors. The use of different gases and contrast media has already been commented upon. The site of puncture of the knee joint varies from just lateral to the patellar tendon upward to the supra-patellar pouch. The amount of the medium or media injected has been standardized by a few authors only. Different writers have recommended different planes for the x-ray views. Neither has there been more than a general



Fig 3

Fig 3 Normal anteroposterior pneumoradiograph of the knee. The upper limit of the cartilage shadows is shown by the arrows.



Fig 4

Fig 4 Normal lateromedial airgram of the same knee as shown in Figure 3. The upper and lower limits of the posterior portion of the medial semilunar cartilage are shown by the arrows. The anterior attachment of the meniscus is not well outlined.

potential sequelæ. Infection has been advanced as an unavoidable result in a certain percentage of cases with resulting pyoarthrosis and ankylosis. In our own series there has been no such untoward happen-

similarity in the post-injection care of the patient.

Our interest in the possibility of more exact diagnosis of meniscal lesions by pneumoradiography was stimulated by the



Fig 9

Fig 9 Lateromedial pneumoradiograph of the same knee (Fig 8). The arrow shows the partly torn and posteriorly displaced posterior portion of the medial meniscus. Anterior to it may be seen the displaced internal portion of the cartilage which lay in the intercondylar groove.



Fig 10

Fig 10 Anteroposterior pneumoradiograph of the right knee of a football player. Arrows No 1 outline the upper limits of a thinned medial semilunar cartilage. Arrow No 2 demonstrates a tear of the lateral semilunar cartilage.

Another factor that caused some difficulty at the outset was infiltration of the pericapsular muscle planes with air, which occurred following injections by the lateral patellar route because of the high pressure. Since it was deemed advisable to withdraw the needle each time before the x-ray exposure was made, to prevent its shadow from causing diagnostic difficulties, we began following Kleinberg's (17) method of inserting the needle, *i.e.*, just lateral to the patellar tendon. While the knee joint is slightly more difficult to reach through

the ligamentum mucosum, this structure acts as a check valve after withdrawal of the needle, preventing escape of the air into the intermuscular planes or subcutaneous tissues. There have been no ill effects apparent even in those cases which have been operated upon within 24 hours after the pneumarthrosis.

Following the taking of the radiograph, the greater portion of the air is allowed to escape. The remainder we have found to be absorbed within from 24 to 36 hours, confirming the observation of others. We



Fig 7

Fig 8

Fig 7 Lateromedial view of the same knee as shown in Figure 6. The arrows show the anterior and downward "pouching" of the alar ligament, which normally (Fig 5) continues from the lower patellar border to the upper tibia in a gentle uninterrupted curve.

Fig 8 Anteroposterior pneumoradiograph of the right knee of a football player who complained of knee instability. There was slight limitation of extension, but no locking. There is an air shadow separating the peripheral (arrow No 1) and internal (arrows No 2) portions of the medial meniscus. The diagnosis of a bucket-handle tear of the cartilage was confirmed at operation.

latter employed from 40 to 50 mm Hg pressure. Bernstein and Arens (3) used 75 c.c. of carbon dioxide routinely in all joints for diagnostic purposes. Others have recommended distention to the point of discomfort. After considerable trial we found that a pressure of 160 mm Hg (aneroid or mercury sphygmomanometer) inflated the joint uniformly, and that the soft tissues as seen in the x-ray films were comparable in density and position. By adhering to this routine, the matter of diagnosis has been, in our opinion, greatly simplified and improved.

Some earlier authors carried out the pneumarthrosis under rigid aseptic technique, performing the injection in the operating room. Others, no less successful in avoiding complications, carried out the procedure in the x-ray room, using ordinary antiseptics to sterilize the skin and employing sterilized instruments. As the latter method was the more simple, and as simplicity was desirable, we have used it, with no regrets. The use of radiopaque solutions, while apparently innocuous, did not seem justifiable since they admittedly have irritating properties.

in athletic sports) have been radiographed after air injection and subsequently operated upon. From these, 28 cartilages were removed. There were seven cases of both medial and lateral semilunar cartilage damage. In one case among the earlier, a diagnosis of damaged lateral cartilage was made but proved, at operation, to be Hoffa's disease. One other case, diagnosed as a double meniscal injury, showed severe medial but apparently no lateral cartilage damage when inspected from the medial incision. Of the cases operated upon, this represents a correct diagnosis of 92.9 per cent of the cases. This percentage may actually be higher, as the last mentioned case has not yet resumed full function.

#### SUMMARY

A brief historical summary of pneumoradiography of the knee has been presented, together with a discussion of the indications and justification for its use, particularly in meniscal lesions. The diagnosis of lesions of other soft tissues within the knee is not commented upon, since our interest has been centered on traumatic damage to the semilunar cartilages, particularly those sustained in athletics. Our technic has been outlined and compared with that of other workers. The roentgen diagnosis of medial and lateral meniscus injuries has been discussed. The percentage of correct diagnoses in proportion to those cases proved at operation has been given.

#### CONCLUSIONS

- (1) A new method for obtaining standardized airgrams is presented, utilizing a uniform intra-articular pressure.
- (2) Pneumoradiography is a certain aid in the diagnosis of obscure knee joint lesions of traumatic origin.
- (3) Pneumarthrosis is an innocuous procedure when average precautions are used.
- (4) In our series at least 92.9 per cent

of semilunar cartilage injuries were correctly diagnosed pre-operatively.

- (5) Pneumoradiography will further reduce the number of exploratory arthrotomies.

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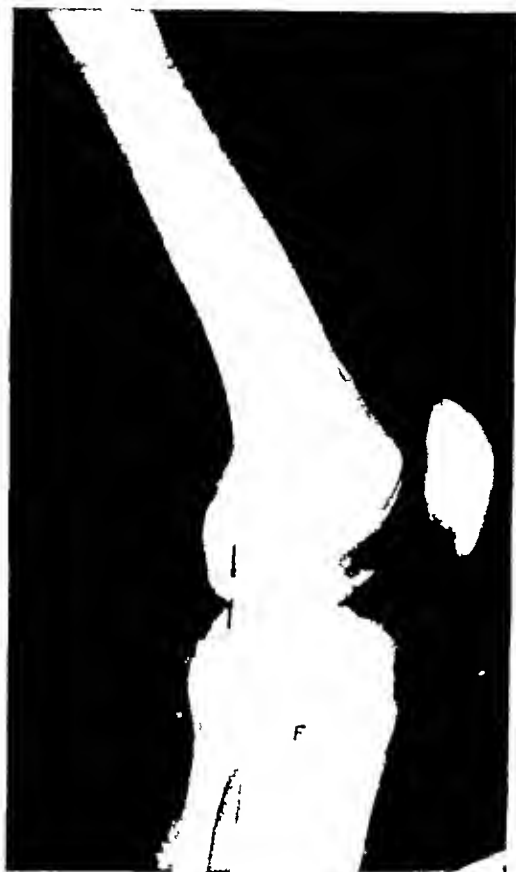


Fig 11 Mediolateral pneumoradiograph of the same knee as shown in Figure 10. The arrows show the site of the lateral meniscal tear noted in the previous view.

have observed no sequelæ of any importance following pneumarthrosis. The "rattling" of the remaining air in the joint has been the most serious complaint by the patients.

Generally speaking, three views have been taken, an anteroposterior, a lateromedial, and a mediolateral. The anteroposterior view is taken preferably with the knee in about  $20^\circ$  flexion, the leg lying parallel to the table. The lateromedial and mediolateral views are taken with the knee in extension and the leg and thigh parallel to the table. Some postero-anterior views have been taken, but, unless extreme care is used, the film is valueless because of overlapping and confusing shadows. Oberholzer (23) has insisted on the value of oblique views, we have not

used them but are convinced that in some cases the diagnosis, particularly of posterior third tears of the menisci, would have been made more apparent.

As has been frequently emphasized, air is the medium most readily available. We first employed it after filtering through sterile cotton, however, since there seemed to be no demonstrable difference between the joint reaction to filtered and unfiltered air the latter has since been our standard.

Our diagnostic criteria for the medial and lateral menisci have been the same save in one respect, *viz*, when air underlies the cartilage. The attachment of the coronary ligament to the lateral cartilage is longer, and this meniscus is more mobile than the medial, which is the apparent explanation for the film of air that most frequently is seen beneath the normal lateral meniscus. Air underlying the medial meniscus has always been, in our experience, indicative of some type of pathology. Otherwise, the criteria for diagnosis of semilunar cartilage lesions may be listed as follows:

- (1) Air outlining a torn or displaced portion of the cartilage.
- (2) Posterior displacement of the posterior portion of the cartilage.
- (3) Anterior displacement of the anterior portion of the cartilage. In many instances the anterior end is not visible and the tear is evidenced solely by an anterior and downward pouching of the alar ligament.
- (4) An "air replacement" shadow which separates the peripheral and internal portions of the cartilage. This is diagnostic of "bucket handle" tears.

As Oberholzer (23) has emphasized, pneumoradiography is not infallible. Undoubtedly many small tears of the menisci are not diagnosed, however, these lesions would be treated conservatively in any event. Further, by its use, needless exploratory arthrotomies are avoided, while those that are necessary are performed before needless damage is sustained by the joint cartilage.

To date, 21 cases of traumatic knee injuries (of which all save four were sustained

## ROENTGENOGRAPHIC DEMONSTRATION OF THE TRUE ARTICULAR SPACE

By BERNARD P. WIDMANN, M D, and WILLIAM R. STECHER, M D, *Philadelphia*

It is essential to realize that the articular space, as commonly referred to by most roentgenologists, is a misnomer, inasmuch as this designated space roentgenologically represents that portion of the joint which is relatively radiolucent, and corresponds to the distance between the osseous ends of the apposing surfaces. This comprises, in the diarthroses or freely movable articulations, the contiguous osseous surfaces covered by articular cartilage, and connected by ligaments lined with synovial membrane. This joint may be divided by an articular disc or meniscus, the periphery of which is continuous with the fibrous capsule, and its free surfaces likewise covered by synovial membrane. This potential space, intervening and enclosed by synovial membrane, is the true articular space, and changes in width, according to varying stress and strain. There is normally a slight amount of synovial fluid contained in this space, the presence of which probably tends to make the roentgenographic visualization of this space difficult.

Prior to the work of Dittmar (1), it had been erroneously considered that this true articular space was never roentgenologically demonstrable under normal conditions. Dittmar demonstrated this space without artificial filling, in the knee joints of children, and stated that this was occasionally noted in normal knee joints in children but never in adults, unless there was concomitant pathologic involvement. It is this latter statement which we wish to correct or modify, for we have been fortunate in demonstrating the true articular space in children, adolescents, and adults, in cases in which no history of trauma or disease was elicited. It is our conviction that, under optimum and coincidental conditions, this space is visible under normal conditions, with improved technic and if attention is focussed upon this phenomenon. To attest for the latter statement,

since recognizing the first reported case of articular visualization, we were surprised at the number of cases presenting this appearance when particular stress was apportioned to this region, and search made for the entity.

In the main, we were unable to duplicate the excellent results in the visualization of the semilunar cartilage of the knee, as outlined by Dittmar, who recommends special technic. This consists of obtaining the ordinary anteroposterior projection of both knee joint regions and, additionally, with the knees in position of passively induced valgus. This method is of especial importance in examination of children's knees, inasmuch as a fair percentage present normally visualized articular spaces in the medial aspect of the articulations. Thus by comparing the two knee joints, one can determine the variance in size of the medially situated triangular shadow projecting into the space medio-laterally. This shadow is the medial semilunar cartilage cross-section viewed *in situ*, and any definable alteration of its normal shape can readily be noted. This type of examination should be performed in all cases of injury to the knee joint region that present suspicious signs and concomitant lateral amphiarthrotic mobility.

Unaware of Dittmar's original work, we independently noted this phenomenon of visualization of the true articular space in the shoulder of an adolescent. Inasmuch as this condition was considered never to be present normally and not visible by ordinary methods of examination, the roentgenograms were presented at a radiological conference. Every radiologist present unqualifiedly affirmed this assumption, and the question arose as to how gas entered the articular space, for none—among the number, some of wide experience—had ever visualized this space without the aid of air injection, etc. The paradoxical condition existed that the articular space



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normal adult articulations, but is always associated with pathology. Thus far we have disproven this assumption in two cases of shoulder joint visualizations, but not in the knee joints of adults, and therefore we concur in this statement only as regards the knee joint. It is very likely that this inference is incorrect, for it is readily conceivable that in the near future, this appearance will similarly be shown in the knee joint, as our attention is now drawn to this entity, and as more cases are under observation. Thus far, for patent reasons, we have been unable to find any practical application as regards visualization of the articular space of the shoulder joint, but it is of importance to know that this phenomenon can exist normally and therefore attach no pathologic import to the examination, when found.

For the sake of brevity, we are presenting three case reports of this phenomenon, in an adolescent shoulder joint, in a child's knee joint, and in an adult shoulder joint, from a group of these cases. We are unable to state the frequency of their visualization, because the number of cases is much too small for worth-while statistical survey. We are under the impression that in at least 10 to 20 per cent of children's knee joints will present this space, and probably no more than 5 per cent of adult shoulder joints. In practically every case, the articular space was outlined bilaterally in the knee joints of children, whereas contrariwise, none was amenable to roentgenographic demonstration bilaterally in the adult shoulder joints. This latter finding is probably due to the relatively few cases observed.

#### CASE REPORTS

**Case 1** A S., a 17-year-old male, was injured in a football game and examined the same day. The provisional clinical diagnosis was possible fracture of the right clavicle. Roentgenographic examination disclosed no demonstrable evidence of fracture, subluxation, anomaly, or osseous pathologic changes about the bones comprising the right shoulder girdle. The left

shoulder girdle presented essentially analogous findings except for visualization of the true articular space, which was approxi-

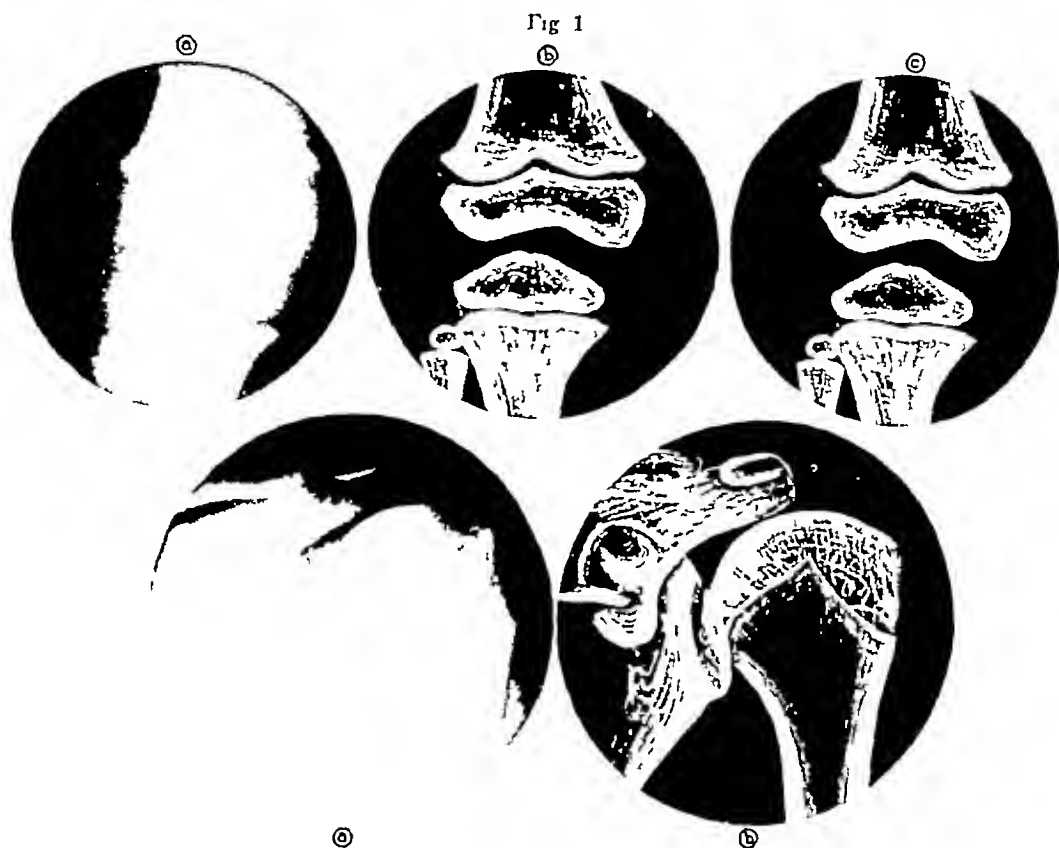


Fig 3 The dark fissure paralleling the humeral head border, is sharply defined and of relatively narrow width

mately 2.0 cm in length, and paralleling the convex apposing surface of the humeral articular head. It averaged 1.0 mm in width. Close questioning relevant to any recent or antecedent injury, disease, etc., of this shoulder joint, elicited no positive information, and physical examination showed no evidence of anatomic or physiologic disturbance. (See Figs 2-A and 2-B.)

**Case 2** R S., aged four years, male. The chief complaint was inability to extend the right leg due to pain in the knee joint. He presented a history of having fallen upon this knee, one week prior to the roentgenographic examination. The pain had become slightly but definitely increased in severity. Localized tenderness was elicited over the tibial tubercle. Roentgenographic examination of both knee joints revealed minimal, but definite, roughening of the tibial apophysis, left tibia, compatible with a diagnosis of early osteochondritis (tibial apophysitis of Os-good-Schlatter). There was no definable involvement of the articular space, but curiously both knee joints presented visualization of the medial half of the true

was visualized in the control roentgenogram of a normal joint. In retrospect, one might explain this appearance as being known. We are of the opinion that this space has heretofore been poorly outlined, and that, due to the vast improvement in



Figs 1 A, 1-B and 1 C (above) Fig 1 A Showing faint but definite outline of the medial portion of the true articular space

Fig 1-B Diagrammatic skeletal of the same region

Fig 1-C The same knee, employing Dittmar's technique, of passively induced valgus. Note the increased width of the articular space and the well defined triangular indentation upon its medial most aspect, which is a cross sectional view of the medial semi lunar cartilage

Figs 2 A and 2 B (below) A Although faintly outlined, the crescentic outline of the articular space is definitely visualized B Tracing of the same roentgenogram to illustrate the rather inordinate width of the space

compatible with a lesser amount of synovial fluid and no periarticular edema or hemorrhage on the uninjured side, which permits of better visualization of soft tissue detail

The question naturally arises, why this appearance had not been noted prior to Dittmar's and our own reports. It probably is true that this condition has been given no particular emphasis and was noticed, but not considered of any significance, or, more likely, its nature was not

roentgenologic technique, particularly of extremely fine line focus tubes, we are actually observing more detail and minutiae of both osseous and soft tissues than was possible, prior to the introduction of these modern methods

To date, Dittmar's demonstration of medial semilunar cartilage disturbance, particularly in children's knees, is the only practical application described. As stated before, Dittmar claims that visualization of the true articular space never occurs in

normal adult articulations, but is always associated with pathology. Thus far we have disproven this assumption in two cases of shoulder joint visualizations, but not in the knee joints of adults, and therefore we concur in this statement only as regards the knee joint. It is very likely that this inference is incorrect, for it is readily conceivable that in the near future, this appearance will similarly be shown in the knee joint, as our attention is now drawn to this entity, and as more cases are under observation. Thus far, for patent reasons, we have been unable to find any practical application as regards visualization of the articular space of the shoulder joint, but it is of importance to know that this phenomenon can exist normally and therefore attach no pathologic import to the examination, when found.

For the sake of brevity, we are presenting three case reports of this phenomenon, in an adolescent shoulder joint, in a child's knee joint, and in an adult shoulder joint, from a group of these cases. We are unable to state the frequency of their visualization, because the number of cases is much too small for worth-while statistical survey. We are under the impression that in at least 10 to 20 per cent of children's knee joints will present this space, and probably no more than 5 per cent of adult shoulder joints. In practically every case, the articular space was outlined bilaterally in the knee joints of children, whereas contrariwise, none was amenable to roentgenographic demonstration bilaterally in the adult shoulder joints. This latter finding is probably due to the relatively few cases observed.

#### CASE REPORTS

**Case 1** A. S., a 17-year-old male, was injured in a football game and examined the same day. The provisional clinical diagnosis was possible fracture of the right clavicle. Roentgenographic examination disclosed no demonstrable evidence of fracture, subluxation, anomaly, or osseous pathologic changes about the bones comprising the right shoulder girdle. The left

shoulder girdle presented essentially analogous findings except for visualization of the true articular space, which was approxi-



Fig. 3 The dark fissure paralleling the humeral head border is sharply defined and of relatively narrow width.

mately 2.0 cm in length, and paralleling the convex apposing surface of the humeral articular head. It averaged 1.0 mm in width. Close questioning relevant to any recent or antecedent injury, disease, etc., of this shoulder joint, elicited no positive information, and physical examination showed no evidence of anatomic or physiologic disturbance. (See Figs 2-A and 2-B.)

**Case 2** R. S., aged four years, male. The chief complaint was inability to extend the right leg due to pain in the knee joint. He presented a history of having fallen upon this knee, one week prior to the roentgenographic examination. The pain had become slightly but definitely increased in severity. Localized tenderness was elicited over the tibial tubercle. Roentgenographic examination of both knee joints revealed minimal, but definite, roughening of the tibial apophysis, left tibia, compatible with a diagnosis of early osteochondritis (tibial apophysitis of Os-good-Schlatter). There was no definable involvement of the articular space, but curiously both knee joints presented visualization of the medial half of the true

articular space of approximately equal clarity and width. An attempt at visualization of the medial semilunar cartilage was unsuccessful, possibly due to the attendant pain and involuntary spastic resistance (See Figs 1-A and 1-B).

Case 3 W R, male, 37 years of age. There was a history, essentially that of trauma by a falling ladder, against the lower right scapular region. No clinical signs of fracture were definable. Roentgenographic examination of the right shoulder joint was essentially negative with particular reference to fracture and subluxation. The opposite control shoulder presented no abnormal findings. As illustrated in Figure 3, there was excellent visualization of the articular space of the right shoulder joint, there being a crescentic dark fissure, of approximately 2.0 cm in length and 0.5 mm in width.

Other cases have been noted in the knee joints of children but presented no further additional diagnostic appearances or changes than that described above. It

is to be noted, that the roentgenograms were obtained, by three different techniques, namely, non-screen, in children, screen technic in the adolescent shoulder, and a Potter-Bucky diaphragm in the adult shoulder. In the shoulder examinations, best results were obtained with the humerus in the position of rest, namely, mid-external and internal rotation. It is possible to mask the articular space visualization by excessive rotation of the humerus, and this might possibly account for the infrequent visualization, in the routine shoulder examination.

To date, we have been unsuccessful in visualizing the true articular space in other joints, and it seems strange that we have been unable to accomplish this, particularly in regards to the hip joint.

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# CONCURRENCE OF OSTEOGENIC SARCOMA IN TWO SISTERS

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IN February, 1936, two sisters, one 3 and one 11 years of age, were referred to the Department of Radiology with the diagnosis of osteogenic sarcoma for roentgen deep therapy following operation. A review of the literature revealed that, last year, Roberts and Roberts (2) were perhaps the first to report the occurrence of osteo-

genic sarcoma. Roentgenograms taken by the attending physician at home (Fig 1) were interpreted then as osteomyelitis. This film, as well as another (Fig 2), taken on Jan 16, 1936, one day previous to admission to the hospital, shows mottling of the lower end of the femur with definite bone destruction, and an irregular laying



Fig 1

Fig 2

Fig 1 Roentgenogram taken on Jan 7, 1936

Fig 2 Roentgenogram taken on Jan 16, 1936

(Both films were rather light and consequently do not show the pathology as clearly as Figure 3)

genic sarcoma in three members (one brother and two sisters) of the same family. As these authors state, the development of sarcoma in successive generations (3) and in unioval twins has been described (1). Consequently, we thought that it would be of interest to record our observation in the literature.

Case 1. Bc R, X-ray No 5,346, a 3-year-old white girl, was admitted to the orthopedic service (State of Wisconsin General Hospital) on Jan 17, 1936, with a painful swelling just above the right knee. Three weeks before admission the child had fallen on the right knee and a week later

down of new bone in the soft tissue. During the next two weeks the pain and swelling increased gradually.

Physical examination was negative except for the right leg, there was a hard, fusiform tumor mass at the lower end of the femur. The child had a flexion deformity of  $20^{\circ}$  at the knee, with a further range of  $30^{\circ}$ , which was painless. Roentgenograms of the knee showed both a destructive and a productive bone lesion in the lower end of the femur (Fig 3). The tumor had invaded the soft tissue and there were areas of calcification in the invaded region. Roentgenograms of the

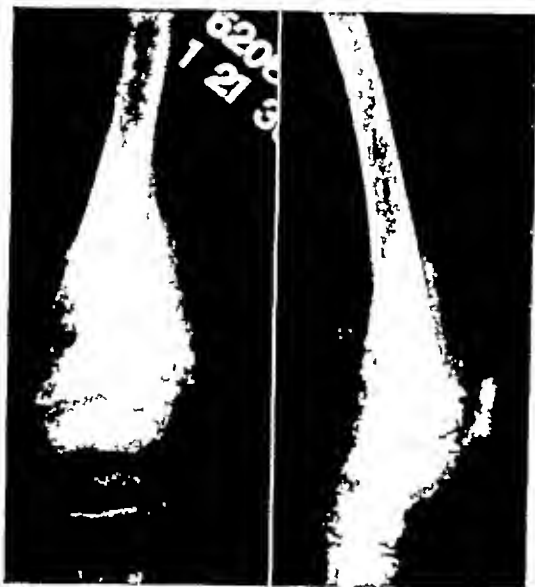


Fig 3 Roentgenogram taken on Jan 17 1936 Mottling of the lower end of the femur with an area of bone destruction is present There is marked periosteal reaction with new bone laid down irregularly in soft tissue

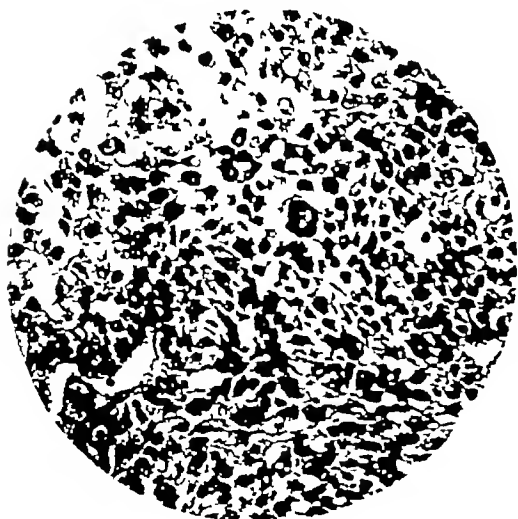


Fig 4 Photomicrograph of No 5346 The tumor is highly cellular contains giant nuclei highly anaplastic cartilaginous elements with mucoid matrix and is very vascular The structure of the tumor varies considerably some sections contain giant spindle cells with abundant myxofibromatous stroma whereas other sections are composed of closely packed large hyperchromatic nuclei and very little stroma There are many atypical mitotic figures One section contains considerable osteoid tissue and calcific deposits Diagnosis osteogenic sarcoma (osteolytic type)



Fig 5 Roentgenogram taken Dec 30 1935 There is a destructive bone lesion of the lower two inches of the ulna involving not only the lower shaft but also the epiphyseal cartilage Periosteal new bone formation is noted on the radial side of the ulna with medullary destruction soft tissue tumefaction and invasion on the distal end of the ulna

chest, skull, and long bones did not reveal any pathologic changes, laboratory findings were not significant

Biopsy was done on Jan 24, 1936, frozen sections showed an osteogenic sarcoma (Fig 4) Amputation just below the hip was performed immediately, this was followed by a series of x-ray deep therapy treatments over the stump and right inguinal region from Feb 12 to 21, 1936

Case 2 Bl R, X-ray No 5,337, an 11-year-old white girl, the sister of Case 1, was admitted to the orthopedic service of the State of Wisconsin General Hospital on Jan 11, 1936, with a history of a small swelling of one month's duration on the

ulnar side of the right wrist. It was painful only when bumped or touched firmly. The family physician had been consulted

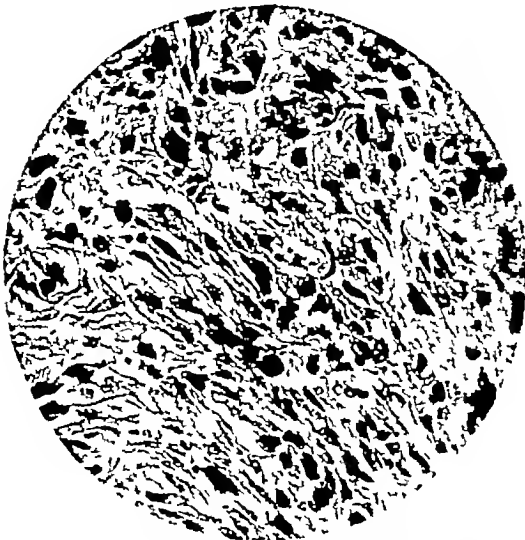


Fig 6 Photomicrogram of No 5337. This tumor is essentially similar to the previously described neoplasm. The sections show a highly malignant neoplasm. The tumor is very cellular and shows considerable nuclear pleomorphism and many mitotic figures. The nuclei vary considerably in size and shape—some are spindle form, some ovoid, and a few are very large and irregular—and most of them contain large nucleoli. Some large nuclei contain as many as three nucleoli. There is quite an abundant fibrillar stroma, and in the less cellular areas the stroma is in the form of ribbon like bands of collagen or hyaline material. The shapes of the cells are too numerous to describe; however, spindle forms predominate, a few multinucleated giant cells are seen. Several islands of osteoid tissue and a few areas of so-called osteoid edema are encountered. A few of the less cellular areas suggest pre-osteous connective tissue. Some of the fragments contain areas of necrosis. Diagnosis: osteogenic sarcoma (osteolytic type).

two weeks after the onset. A roentgenogram was taken on Dec 30, 1935, and a biopsy done on Jan 12, 1936. The roentgenogram (Fig 5) showed a destructive bone lesion of the lower 2 inches of the ulna, involving not only the lower shaft, but also the epiphyseal cartilage. Periosteal new bone formation was noted on the radial side of the ulna with medullary destruction, soft tissue tumefaction, and invasion on the distal end of the ulna. The arm was placed in a cast and no increase in size of the swelling could be noted during the interval between onset of symptoms and admission to hospital.

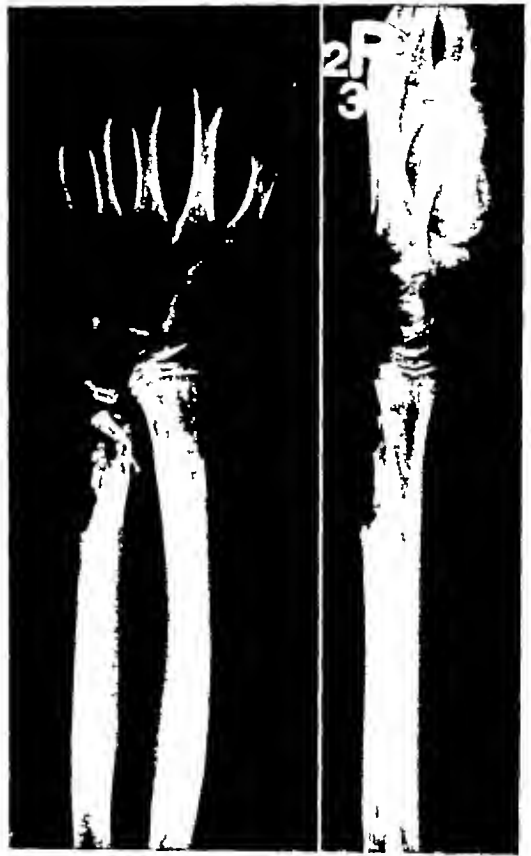


Fig 7 Roentgenogram taken Jan 13, 1936. There is a fracture of the lower end of the right ulna, with floating epiphysis, also there is considerable bone atrophy of the carpus.

When the pathologist returned a diagnosis of highly malignant sarcoma (Fig 6), the child was referred to the University Hospital.

Physical examination was negative except for the right forearm. There was a moderate, uniform swelling over the dorsum of the wrist and lower forearm. An incompletely healed incision over the lower end of the ulna was present and draining slightly.

Roentgenograms taken Jan 13, 1936, showed a fracture of the lower end of the right ulna, with floating epiphysis, and considerable bone atrophy of the carpus (Fig 7). Roentgenograms of the tibiae showed deviation in contour of the right tibia at its proximal end. There was a slight bulging of the cortex, which appeared roughened in this area, but no definite



bone lesion was seen. Bone atrophy was present in both. Roentgenograms of other bones and the chest were negative. Laboratory findings were irrelevant. On Jan 24, 1936, amputation of the right arm at mid-humerus was done. This was followed by a series of x-ray deep therapy treatments over the stump and right axilla from Feb 7 to 18, 1936.

#### COMMENT

We do not wish to deduce from this single observation any conclusions leading to a hypothesis or theory regarding the genetic origin of malignant tumors, or as to the rôle

of any other factors which may be involved in the appearance of sarcoma in members of the same family of the same generation. It is the rarity of this occurrence which led us to publish our experience.

*Note* Since the writing of this report, child Be R (Case 1) has developed metastasis in the right upper lung (Roentgen examination of the chest on Sept 28, 1936).

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# COLOSPASM ITS ROENTGEN DEMONSTRATION AND DIFFERENTIATION

By A GALAMBOS, M D,<sup>1</sup> and W MITTELMANN, M D, *New York City*

THE term "colospasm" should designate certain spastic manifestations of the colon which affect any of its segments. It is not a disease but merely a symptom which is undetectable except by its x-ray demonstration. "Colospasm" denotes only a roentgen diagnosis, regardless of any clinical correlation.

Similar x-ray findings have been described and correlated with "mucous colitis" (Crane) and found pathognomonic, although convincing proof is still lacking. "Mucous colitis" is synonymous with the "irritable colon" (Bargen), the "unstable colon" (Kantor), and the "mucous colopathy" (Barker), among many others.



Fig 1 The "colospasm" typical x ray demonstration. (A) Note the thread-like maximally contracted spastic transverse colon throughout its length, (B) the filiform appearance—the maximal spasm is restricted to the distal portion of the transversum, in (C), after a barium enema, a completely normal (configuration, size) colon is visualized. Patient is a highly neurotic young female.

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listed by Barker and also by Crane. The proper understanding and interpretation of this relatively frequent roentgen sign is



Fig 2 Spasm of the transverse and descending colon. Note the sudden inception and termination of the spasm. Diagnosis: acute peptic ulcer without neurotic components.

important and its differentiation should be stressed.

The literature on this topic is very mea-

ger and confusing. Crane, who first called attention to this x-ray sign, states that "it suffered a curious and extraordinary neglect at the hand of both the internist and roentgenologist." This must be true, in view of the fact that this x-ray sign has been described only as recently as 1927. In spite of this fact, and though in apparent contrast thereto, the disease itself is extremely frequent. Kantor emphasizes that the "unstable colon" is one of the most common and disabling diseases encountered in medical practice." This apparent contrast between the actual frequency of the disease and its erroneous classification and confused interpretation in the literature, as well as its neglected x-ray study, until late, is indeed quite striking. In the introduction of her writing on the "unstable colon," S. M. Jordan likewise refers to the state of "confusion which exists at present in the minds of most physicians in regard to the term 'irritable' or 'unstable colon' and its relationship to



Fig 3

Fig 3 Spasm of the transverse and descending colon with interpolation of a barium filled segment of an egg sized area on the descending colon. Note small 24 hour gastric residue. Diagnosis: double cancer of the stomach (operation). Patient is not neurotic.



Fig 4

Fig 4 Spastic narrowing of the descending colon in a highly neurotic male. Note the abrupt onset of the incomplete spasm.



Fig 5



Fig 6

Fig 5 Spasm of the proximal third of the transverse colon. Note the sudden transition. The control film shows normal configuration. A neurotic patient suffering from recurring duodenal ulcer.

Fig 6 Spastic narrowing and segmented filling of the descending colon over a circumscribed small area. The sudden onset, the curved shape and reduced width of the viscus resembles an appendix with a wide lumen. Diagnosis: chronic duodenal ulcer.

neurosis, etc." Crane emphasizes with inspired and polemical pathos the great confusion concerning this topic, the polypragmasia in reference to the clinical terminology, in contrast to the scarcity of intelligent description and confusing clinical interpretation of the disease, and still more so, the failure of its roentgenologic approach.

The loose, injudicious use of the term "colitis," in any connection relative to an actual or assumed functional abnormality, is so misleading, confusing, erroneous, and unscientific that the frank and straightforward suggestion of Sidney A. Portis, who emphatically recommends that "the word 'colitis' should be deleted from medical literature, unless there exists an actual organic involvement of the large bowel," should be met with general approval.

The contradiction and confusion are dramatically demonstrated by the fitting characterization of Crane "notwithstanding centuries of extensive clinical observation, the present-day authorities show interesting differences of opinion and often



Fig 7 Spasm of the distal portion of the transverse colon. Its failure to fill its middle portion is possibly due to pressure from the spine. Note that this illustration is a reverse.

between-line evidence that the writers have had very limited personal experience with cases of this disease." In other words, a disease, generally known for a long time under various terms, in spite of this frequency was barely understood by the individual observer. The new names and synonyms applied tried to cover the ignorance underneath, but failed to clear the



Fig 8 Spastic narrowing of a redundant mass of the descending colon over a circumscribed area, in sharp contrast to the wide lumen of the other part of the colon

faulty conception. In spite of its frequency, Crane states "In various other well-known works, medical, surgical, and diagnostic, mucous colitis is either not mentioned or else dealt with so briefly and in such general terms as to be without value."

Bargen, assailing the vagueness of the term "colitis," states "When the term 'colitis' is applied only to infectious and inflammatory lesions of the large intestine, untold physical and mental anguish and suffering will be eliminated."

"Mucous colitis" or any of its variants, in spite of the fact that they are termed "colitis," is not a genuine colitis. In fact, such terms not only fail to signify a true inflammation of the colon, but they do not even represent a functional disease of it, because they are primarily parts of a general bodily state (Barker), the enteropathy being associated with a neuropathic constitution. Bargen sees the primary cause of a mucous colitis in the patient's make-up. According to Friedenwald, Feldman, and Rosenthal, the instability of the nervous system prepares the patient for the



A



B

Fig 9 Spasm in the duodenum (A) The descending portion shows a linear spasm (B) shows a cork-screwlike spasm. Patient who is not of a nervous type, suffers from a duodenal ulcer located at a higher segment

condition P W Brown equally condemns the use of the term "colitis," and similarly subordinates the same to a bodily

by no means pathognomonic of this condition, as will be shown later

(D) The string-sign is supposed to repre-



Fig 10 Linear spasm of the terminal ileum Control shows normal coil Obscure abdominal pain relieved by anti malarial treatment

condition Hurst significantly states, in discussing the problem of "colitis" that, "No diagnosis is made more frequently and with less justification "

The confusing and misleading facts and factors in this problem-complex, with a few suggestions for their correction, in my opinion, could be summed up as follows

(A) "Mucous colitis" (colitis mucosa) and all of its variant names actually intend to be used for, and should be identified as "mucous colic" (colica mucosa)

(B) Colica mucosa is well known as the classical manifestation of the vagotonic condition It is only one symptom, one localization of that general status, or bodily state, and in itself is not a disease *sui generis*, and should be so understood and correlated

(C) The "string-sign" has nothing to do with "mucous colitis", it is rather the x-ray demonstration of colica mucosa, but, while colica mucosa has the string-sign as its x-ray demonstration, the string-sign is

sent the maximal contraction of the colon of spastic origin The term "colospasm" is, consequently, more suitable and descriptive for the spastically contracted colon Any other maximally narrowed lumen of the colon or even of the small intestine, due to any cause, organic or inorganic, such as an extrinsic compression or an intrinsic encroachment upon the lumen by a tumor, granuloma etc, is or may be designated by the term of "string-sign," as applied by Kantor for the narrowed ileal coils in case of "terminal ileitis" "Colospasm" should not only designate a contracted, maximally narrowed lumen, but one caused by spasm only, excluding any organic origin Colospasm is the term for a purely roentgen manifestation, not having any reference to the clinical side, cause, or interpretation of the case

(E) Because all of the synonyms for "mucous colitis" are confusing, misleading, misrepresenting, and unnecessary, they should be discarded altogether

(F) "Mucous colitis" proper, in suitable cases, could be better replaced by the term



Fig 11

Fig 11 Spasm of the terminal ileum Note the rugal outline Incidental findings in a seemingly healthy boy



Fig 12

Fig 12 Spasm of the terminal ileum Dotted appearance of the external outline Note the crossing with the appendix Simultaneous colonic spasms were noted Diagnosis duodenal ulcer

"catarrhal colitis," which refers to the appropriate, mild cases of inflammation of the colon

#### THE CHARACTERISTIC FEATURES AND THE DIFFERENTIATION OF THE "COLOSPASM"

(1) The spastically contracted colon, in well-defined cases, produces a sharply outlined, straight or slightly irregular, very rarely spiral, linear marking, a long, thin "string" or thread of a hair-pin thickness, generally resembling a visualized lumen of an average, or still more appropriately, a narrow, atrophic appendicular lumen, the contraction, however, usually extending over a much greater length. In less pronounced cases the contracted lumen is thicker, heavier, and less characteristic, it may be interrupted, dotted, conical, or slightly feathery, but the latter is exceptional. Haustral markings and innerfolds are completely missed. The points of import, in reference to the more proper designation by "colospasm," as against the "string-sign," were discussed above

(2) In rare cases, the contraction may affect any segment of the colon, or only the terminal portion of the ileum at its cecal juncture, or some part of the duodenum, and in extremely rare cases even the appendix. The location over either the transverse or the descending colon, or both, is most frequent. While the process extends as a rule over a larger stretch of the colon, generally a third or a fourth of its entire length is affected, at times, the spasm remaining restricted to a stretch of a few inches only.

(3) The spasm has a very definite shifting character, as a result of which a spastic contraction over the middle portion of the transversum may alternate, after a few hours, with a similar contraction over the descending colon, with or without a simultaneous disappearance of the former.

(4) The spastic contraction is never followed by a concomitant or compensatory reaction in the dynamics of the proximal portion, as is the case in cardiospasm or even in a long-continued pylorospasm.

(a compensatory hypertrophy giving way later to a secondary dilation) Colospasm does not seriously interfere with the pass-

(5) The colospasm itself is always of good prognosis, it shifts, disappears, and causes no secondary changes. However,



Fig. 13 Post defecation film of the colon. Note in (A) the tapering start in the distal segment of the transversum, in (B), the sharply angulated course of the aboral portion of the transversum, in (C) the rather unusual pattern of the haustral markings. In all three films after the evacuation of the bulk of the opaque material some of the remnants visualize the mucosal rugal outlines in a more or less complete fashion. Additional spastic or other functional factors may superimpose the picture, as in (B).

age and propulsion of the intestinal content, because, irrespective of the completeness of the tonic closure of the lumen, it is always of a temporary nature only. Consequently, the colospasm is not indicative of a permanent or fixed anatomic impairment, not even of a permanent functional derangement. In its presence, no typical, compensatory, nor consecutive changes of any nature are expected to follow.

it may co-exist with or accompany any primarily existing organic disease, tumor, etc., anywhere in the abdomen, consequently, while the colospasm as such is always of good prognosis, its presence, for the latter reason, still does not necessarily imply a good prognosis.

(6) The colonic spasm, as evidenced on films after the barium meals, disappears as soon as the opaque material is administered by rectal enema, proving that the





Fig 14 Post-defecational films—various patterns

direct cause for the narrowing of the lumen is not to be looked for in anatomic structural changes (stricture, compression, infiltration, encroachment, etc.)

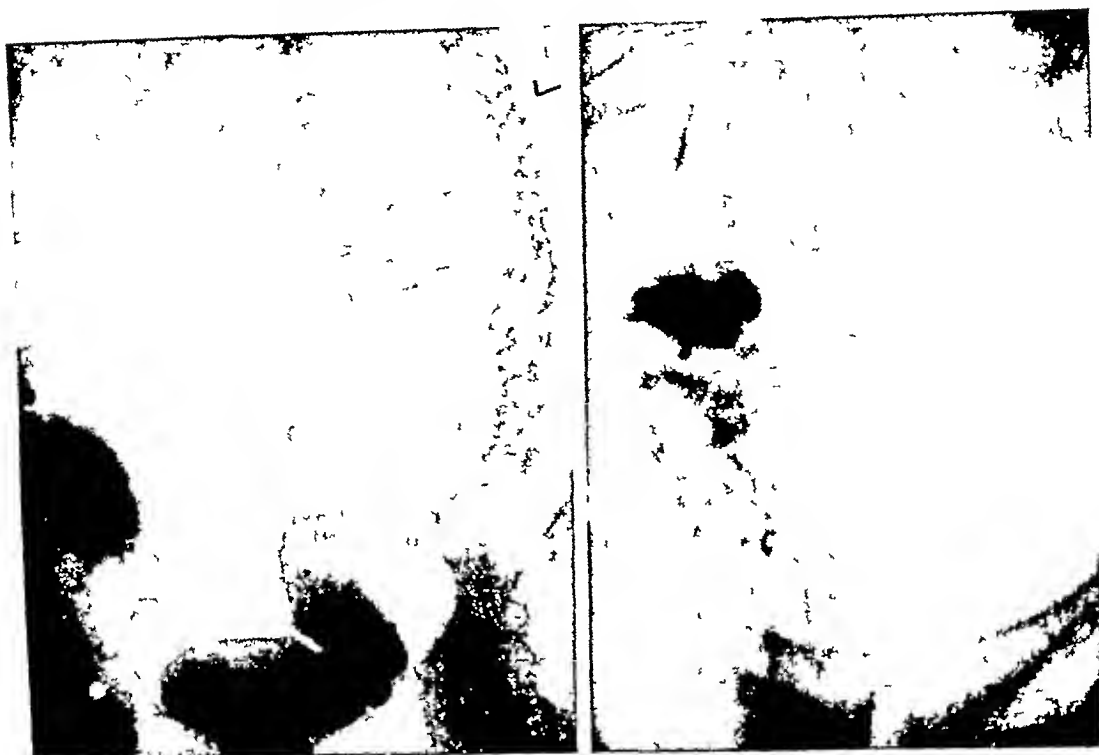
(7) Spastic contractions over the colon are often associated with spasm encountered in other parts of the alimentary canal (esophagus, stomach, duodenum, ileum, appendix), or even over the gall bladder, proving that the spasm represents a generalized, systemic reaction of the individual.

(8) Colospasm may be considered as an expression or stigma of a neurogen or psychogen disposition, if the individual happens to suffer, among other things, from intestinal disorder, the syndrome-complex often but not necessarily is "colica

mucosa." Colospasm may be present in the latter condition, but also in the absence of any vagotomic symptoms or even abdominal complaints, merely as a graphic demonstration, or a stigma of a psychoneurotic condition. Furthermore, colospasm is often demonstrated as an incidental finding, as a secondary accompaniment to any abdominal organic disease (such as cholelithiasis, appendicitis, peptic ulcer, carcinoma, etc.), with or without a neurotic base.

(9) "Mucous colitis" is identical with "catarrhal colitis," but with none of its synonyms. This condition, as its name indicates, designates an actual, though mild inflammation or a catarrhal condition, the catarrhal or the inflammatory product being "mucus." The term does not reflect upon the etiology, pathology, or even the clinical terminology of the underlying condition. Any inflammation or ulcerative process (dysentery, ulcerative colitis, tuberculosis, etc.) in its mildest form, or at its earliest stage, while the inflammatory product is only mucous (without blood, pus, or tissue debris), but only until such a stage, can be called "mucous" colitis.

The x-ray demonstration of the underlying condition reveals pictures different from the ones known for colospasm, or known as "string-like." Although the mildest form may approach the normal, its regular roentgen manifestation may present certain changes, especially in reference to the haustration. The latter may be lessened, smoothed, "ironed-out", it may be irregularly shaped or spaced, or serrated (fibrillation), with an appearance recalling a jejunal shape. The shape may be described as mottled, spotted, marbled, beaded, ragged, shreddy, distorted, flecked, ribbon- or band-like, with a variance in the depths of the intrahaustral clefts, etc. The picture does not reach the typical, un-haustrated, sausage-shaped appearance of the non-specific ulcerative colitis. The differentiation from the maximally narrowed, spastic colon, the picture of "colica mucosa," should not occasion any difficulty. The case is clinically a colitis of a



A

B

Fig 15 Post-defecation film in a highly neurotic individual. In (A) excepting the cecum and the rectosigmoid the entire colon shows a silhouette of its rugal markings. In (B) the rugal outline of the rectum is visualized.

milder degree, as often encountered, developing after a long-continued abuse with cathartics. The mucus recovered in the feces elicits, microscopically, signs of true inflammation, with the presence of white blood cells ensheathed in the mucus.

(10) "Colica mucosa" (mucous colic) is a 'neurosis with visceral manifestations' (Crane). Osler defines the true mucous colitis as 'a secretion neurosis of the large intestine, met with particularly in nervous and hysterical patients.' In Friedenwald, Feldman, and Rosenthal's characterization, "when the balance between the two sets of nerve fibers is interrupted, in that there is overstimulation of the parasympathetic system or inhibition of the sympathetic, secretion of mucus and painful spasm may occur."

Colica mucosa represents no inflammation, and the large amount of mucus detected in the feces shows no signs of any inflammation. White blood cells are ab-

sent. "It is not catarrhal, although it is characterized by the discharge of large quantity of mucus" (Crane). The disease is primarily a neuropsychosis, the intestinal localization being of symptomatic significance only. In vagotomic conditions, sudden, painful abdominal attacks, with the discharge of large amounts of pure, glassy mucus, often giving a tubular innercast of a colonic segment, is the feature of the disease. The mucus can either be mixed with or only cover the fecal matter, or it can be ejected without any fecal admixture. It can be loose or tenacious, its water-suspension indicating its true shape and extent.

Its x-ray demonstration, as pointed out by Crane, in 1927 (he termed it "mucous colitis," but intended to designate "mucous colic"), is that of a "string" shape, morphologically identical with the authors' "colospasm." The "string-sign" is the x-ray manifestation of the "colica mucosa,"

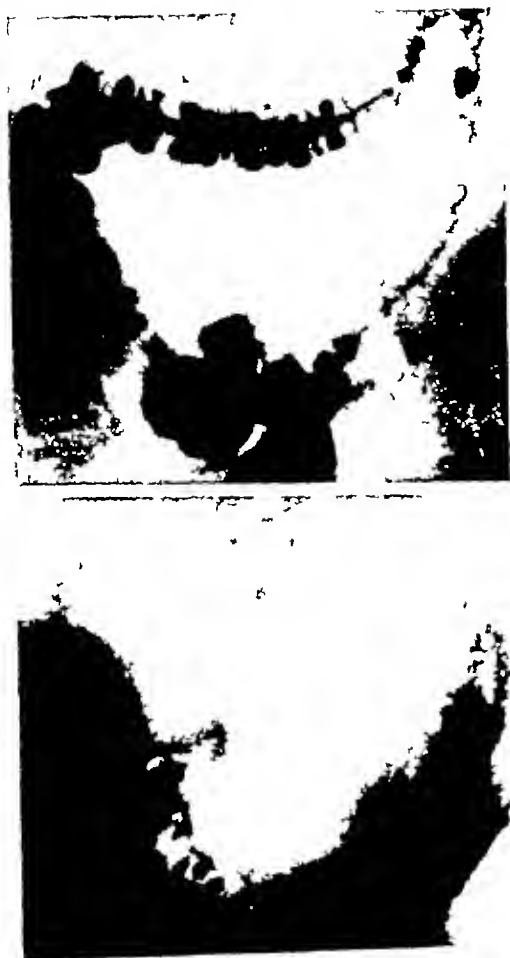


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although patients, especially neurotics, may manifest similar colonic pictures, even without colica mucosa

The vagotonic, the maximally overactive colon, in its paroxysmal, colicky attack, assumes the shape of the overstimulated, maximally hypertonic or spastic colon, which is the customary roentgen manifestation of the clinical condition in question, nevertheless, the "colospasm" or the "string-like" colon is not pathognomonic of the mucous colic, because it may often be encountered without any counterpart in the clinical picture

Exactly identical pictures are rather common findings, as secondary concomitant symptoms, in various abdominal organic lesions, in which the rôle of the nervous system is of little importance. I have occasionally found this colonic spasm in the presence of cancer of the stomach, peptic ulcer, cholelithiasis, appendicitis, etc., without clinical symptoms related to the colon

*Conditions which Roentgenologically may Resemble "Colospasm"*—From the roentgen diagnostic point of view, the picture of colospasm should furthermore be differentiated from the empty colon, from the post-defecational picture, from the tumor-borne filling defect, from the roentgen demonstration of the ulcerative colitis, and from the picture of the failing filling between two barium columns

(A) The picture of the empty colon, more correctly the segment void of opaque material, either because the barium has not entered it as yet or else because the barium has already passed it, is characterized by negative signs. The segment is not visualized. The transition into the barium-containing gut may be abrupt or gradual, in the shape of a conical or tapering picture, more so in the aboral portion in which the inspissated fecal matter shapes itself into a more plastic or solid mass. Any segment of the colon may prove to be empty or become so, but it is rather uncommon between two barium-filled columns, it is more frequent at either end of the visualized gut. A maximal spastic

contraction, an organic or filling defect, producing complete obliteration of the lumen, may mislead in differentiation and



Fig 20 Mild ulcerative colitis in a neurotic male (A above) rectal enema shows a circular spastic ring in the ascending colon. The distal portion of the colon fails to show haustral markings (B, below) under reduced pressure (administration of only one pint of barium emulsion) three spastic circular contractions are visible in the distal colon, not demonstrated at the administration of the regular barium enema (three pints) under higher pressure

interpretation of the borderline cases. Empty colon segments are often produced as a result of a compression in the prone position, due to the pressure of the spine. (B) The post-defecational picture refers to the visualization of the terminal or dis-



Fig 16

Fig 16 Post defecational film, as observed immediately after an *en masse* (Holzknecht) movement after operation for terminal ileitis



Fig 17

Fig 17 Post defecational film—an unusual pattern—with small irregular barium fragments nearly uniformly scattered throughout the colon. Case of terminal ileitis



Fig 18

Fig 18 Post defecational film in an individual with patent valves of Bauhin after a barium enema. The barium filled small intestines are uninfluenced by the defecational act. The colon is emptied completely. The impregnation of the folds renders their visualization nearly as complete as seen after a routine folds-technic



Fig 19

Fig 19 Post-defecation film. Unusual pattern of irregular haustration in patient with constipation (cathartics habit). Note the tendency to spasm in the ascending colon. Partial evacuation after barium enema leaves the distal colon moderately filled, lending a 'colitis like' appearance. Control films show

reading and evaluation of the picture of the aboral colon segment

*The Post-defecational Picture* — It (1) refers to the previously barium-filled segment, (2) affects usually the terminal colonic portion, (3) is visualized only after defecation, (4) is, as a rule, not "string-like," as in spasm, not sausage-shaped, as in severe colitis (although it may resemble it after incomplete evacuation), is rarely completely void of barium remnants, as the empty colon is, is not irregular, "worm-eaten," short stretched, as in the case of tumors. Rather, it unfolds the picture of the mucosal foldings in minute, feathery appearance.

(C) Carcinoma or other malignant tumors, as well as various granulomas, encroaching upon the lumen of the gut, may produce a concentric or an eccentric narrowing. The area of the involvement is not extensive, its penetrating depth varies, and the visualized lumen is marked by an irregular outline (base and edge). The transition into the healthy tissue is a gradual one, rarely abrupt. The irregular filling defect is identical on all the films, regardless of the way in which the opaque material has been administered (rectal or oral), as one would find in anatomically fixed lesions. Development of a compensatory hypertrophy with a secondary dilation of the proximal portion completes the picture. The clinical aspect is that of a malignant tumor. The proper recognition and evaluation is all the more important, because carcinoma of the colon may simultaneously produce colonic spasm, and either of them may be multiplex.

(D) The picture produced by the ulcerative colitis is of an anatomically fixed shape, nearly identical on all the films. It affects the diseased area in its entirety, the changes being most severe, as a rule, in the distal portion. Its extent, affecting usually a large section of the aboral half of the colon, varies. The diseased area is, in the well-marked case, unhausted, rigid, pipe-like, or sausage-shaped, with a uniformly reduced diameter of the lumen, which, however, even in the most severe



Fig 23 Filling defect, more precisely a failure to fill, with irregular, though not ulcerated, outline of the barium shadow due to failure of filling of the segment, after two successive barium intakes (24 and 6 hours, respectively)

cases, does not even approach the thin and string-like appearance of the colospasm. The case clinically is that of a severe colitis.

(E) Very rarely an interesting, in fact, a puzzling, filling defect of the colon may be encountered. In reality, it is not a "filling defect", it is rather a "failing filling" of a certain segment of the colon, due to conditions created by two successive barium meals, several hours apart, when the head of the second filling had not as yet reached the tail of the first filling, leaving a short stretched segment of the colon unfilled. The picture can be further obscured or rendered misleading by the discovery of some small barium remnants or flecks, harbored in the folds or in the lumen of this unfilled area. The unusual morphologic appearance may give rise to differential diagnostic difficulties, especially in the way of excluding spasm or tumor-produced filling defect. The knowledge of this fact (the mere awareness of its existence), the lack of any pathology in the



Fig 21

Fig 21 Ulcerative colitis. Note the irregular haustration of the transversum and the sausage shape of the descending colon. Note its relative width, contrasting spasm.



Fig 22

Fig 22 Cancer of the sigmoid in a young girl aged 20 years (operation). Irregular filling defect of circular shape and of moderate extent and depth.

tal portion of the colon, it is not perfectly uniform. The rectum, sigmoid, and descending colon, rarely the transverse colon, after evacuation of the barium-containing feces, immediately or soon thereafter show certain characteristic features. The transition of the barium-filled colon transcends rather suddenly into the evacuated segment, the shape of the transition is more frequently tapering or conical than abrupt. The emptied segment usually shows barium remnants or streaks of its mucous foldings, in minute, feathery distribution, the picture often resembles the one obtained by using the fold technic. After the bulk of the barium mixture has left the lumen, some of its remnants impregnating the mucosal foldings will be retained there, resulting in a complete visualization of the mucosal foldings. The barium is rarely found in the shape of a solid mass or of a "string", it is mostly loose, flocculent,

feathery, infinitesimally minute, and retained in the folds of the mucous membrane. Diminished size, unhausted form, beaded or serrated shape, diffusely reduced barium content of the colon, lending the appearance of a barium "sprinkling" only, are by no means rare observations.

It may occur that, after a fractional or incomplete defecation, in spite of an extensive evacuation, nevertheless, some barium mass will remain in the rectum, and even in the sigmoid. The x-ray film should be interpreted in complete awareness of the history of the previous bowel movement. The differentiation, especially from the "colospasm" in rare instances, is hardly possible, and in such cases the knowledge of the last defecation is the *sine qua non* of the proper interpretation of the case. These findings should not mislead or counterprove the correct

# HISTORADIOGRAPHY

A NEW APPLICATION OF X-RAYS

By PAUL LAMARQUE, M D, Professor of Radiology, University of Montpellier, France

IN RADIOLOGIC routine, natural or artificial differences of density must exist in order to obtain shadows which can be interpreted. In operating in the usual way, under 50 kv potential, rarely is one able to differentiate tissues which are of nearly the same density. Also, the grain of extremely rapid x-ray films is always very large and can hardly support enlargement. The thickness of the tissues examined is such that diffused rays play an important rôle.

When the object to be examined is thin and non-dense, it is necessary to lower the voltage, *i e*, to lessen the mean wave length of the x-ray beam, which at once gives rise to difficulties.

Goby (1913-1925) presented, before L' Académie des Sciences, radiographs of small objects and insects taken with soft rays. His work, although of interest, did not bring about any change in the usual technic of x-rays. Under atmospheric pressure, absorption phenomena prevented Goby from making use of the advantages which many soft rays afford in differentiating bodies of neighboring densities. The diffusion of the air played an important rôle and, on the other hand, enlargements could scarcely exceed one-tenth of some diameters.

It was of interest to try to take radiographs of more delicate structures than those studied by Goby. In 1930, Dauvilliers presented a note on radiomicrophotography. He was the first to utilize grainless photographic plates, the negative thus obtained could be greatly enlarged. Using very soft rays he obtained interesting contrasts at a potential of from 7 to 9 kv. To avoid air absorption, the plate and preparation were placed in a special camera through which a current of hydrogen was passed.

It seems interesting to us to recall briefly Dauvilliers' technic, which we have modi-

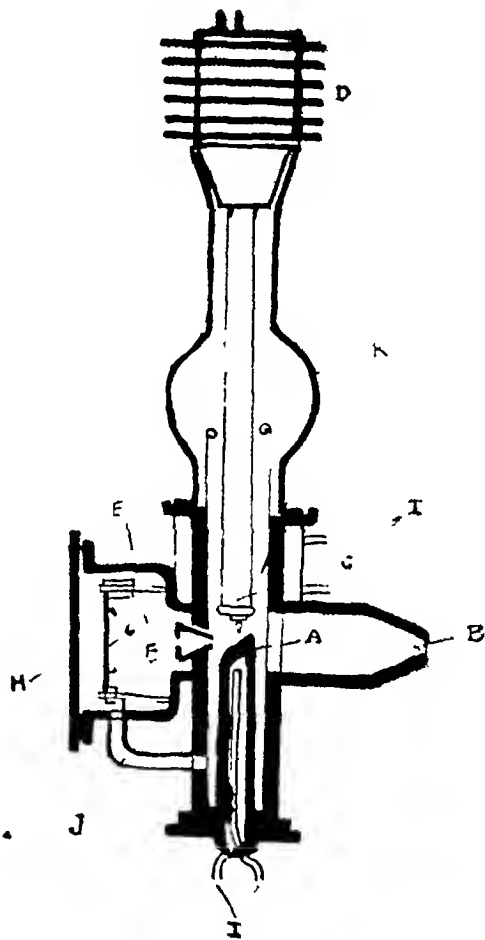


Fig 1 Scheme of the tube (A) Target (B) To the vacuum pump (C) Cathode (D) Air radiator of cathode, (E) Camera, (F) Window with aluminum filter (G) Photographic plate (I) Water cooling

fied slightly. He used a tube which he had made for crystal analysis. It consisted of a metallic body for the anode with an interchangeable target bearing four diaphragms of variable diameters, shut off by aluminum windows which could be attached to hermetically sealed cameras bearing the photographic plates. These cameras were emptied or filled with hydrogen. A pin



clinical picture, and furthermore, the change, the advance, and the eventual refilling, resulting in complete disappearance of this peculiar filling defect (provided that successive films are taken at considerable time intervals), clears the situation

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cient surface The enlargement of the diameters of the apertures was not consistent with their resistance The vacuum system

perpendicular to the axis of the camera A vacuum is obtained in it by means of the vacuum system used for the tube This

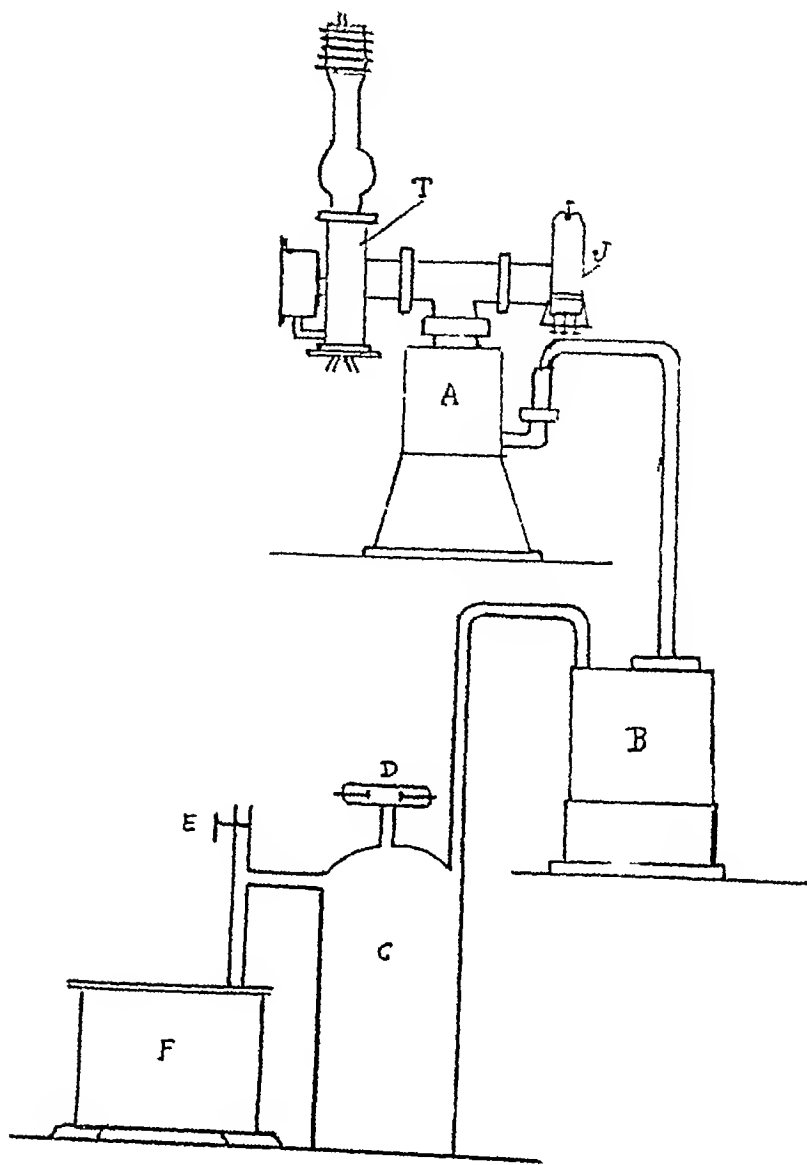
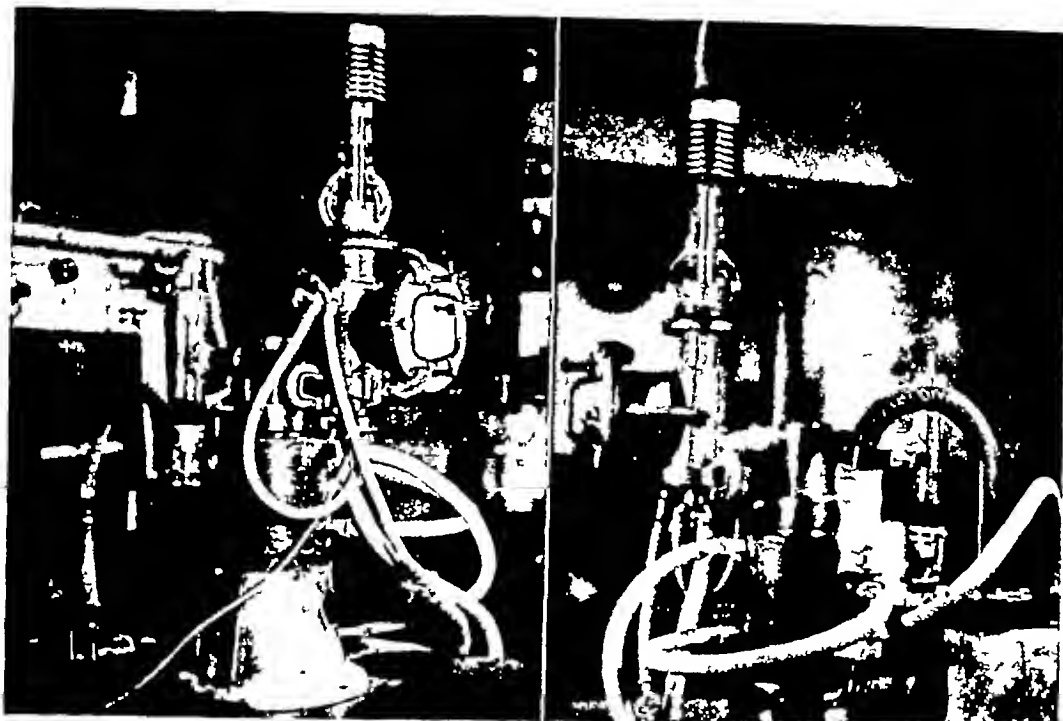


Fig 4 Pumping system (T) Tube, (A) Oil diffusion pump, (B) Mercury diffusion pump, (C) Tank for primary vacuum, (D) Air gauge, (F) Rotating oil pump, (J) Thermionic gauge, (T) X-ray tube

caused vibrations which frequently burst the windows, the latter being necessarily very thin To overcome this, we have made a special camera which is hermetically sealed to the tube, the axis of which is

method, however, presented difficulties, and we have been obliged to make a new tube, which will be described later on The cathode light is screened off from the plate Different filters have been tried very thin



Figs 2 and 3 The x-ray tube mounted on the oil diffusion pump

hole central focus was obtained by means of a Coolidge cathode

The vacuum in the tube was maintained during the manipulations by an oil diffusion vapor pump. The potential applied varied between 7 and 8 kv, with a tungsten target and a current of 0.1 ampere, the time of exposure did not exceed two hours. The plates were reinforced with silver in order to obtain photographic densities which would support greater enlargements.

The preparation is applied directly to the emulsion with a drop of alcohol. After exposure the preparation is removed and the plate is developed and examined under a microscope.

By this method Dauvilliers obtained a fine radiomicrograph of the pith of elder, in which intercellular separations belonging to the microscopic skeleton are perfectly discernible.

*Personal Technic*—Interested by Dauvilliers' work and taking into account all the results which might be useful in microscopic work, we have, since 1931, studied

this technic and have ascertained that while it was relatively easy to radiograph botanical sections, it was certainly more difficult to obtain the same results with animal tissues. From the beginning we have been handicapped by practical difficulties, chiefly in the production of plates and sensitive emulsions which do not exist in commerce, the results obtained are not always those desired, and they are not constant. It is difficult to obtain, in a laboratory which does not specialize, a satisfactory homogeneity of the sensitive layer, a good adherence of the gelatine, and above all, a regular and sufficient sensitiveness. The latter is greatly diminished—about one-thousandth of that of ordinary commercial plates, even the least rapid.

It was this lack of sensitiveness and inconsistency in the results obtained which led us to several modifications in the apparatus. First, we tried to bring the preparation nearer to the target, but the small apertures of the tube had to be enlarged to allow the x-ray beam to spread over a suffi-

camera and there are practically no scattered radiations or absorption by gases. We have been able to reduce the time exposure considerably, from 2 hours (Dauvilliers) to 5 minutes. At the beginning of the research, exposures of 20 hours or more were necessary.

## RESULTS

The radiographic images thus obtained are sharp and clear. We foresee the possibility of much further progress with better vacuum conditions which demand some practice, it is necessary to use only a thin section and to have a perfect adherence between the section and the plate.

The image thus obtained is a negative one, and this presents the greatest obstacle to the histologist who examines it. The parts which are normally light on the colored preparation are often dark on the plate, and *vice versa*. This particularity necessitates a re-education of the eye, which we are persuaded can be quickly accomplished. In the difficult cases it is easy to obtain positive images by photomicrographs which are much simpler to interpret.

We have called the images thus obtained historadiographs, a name which exactly describes the classic microscopic structures, except for rare exceptions, and with some training, will be interpretable.

However, some new unforeseen aspects have been encountered in colored methods. Even with very thin sections considerable variation in opacity exists, some cellular structures absorbing  $\alpha$ -rays more than others.

We cannot quote all the tissues examined, but taking human skin as an example, it is possible to state differences of absorption with regard to the various parts of the epidermic layer.

Periphere cells of the horny layer are extremely opaque and with increasing depth the opacity gradually *lessens*, to arrive at a maximum at the level of the basal cells. This final opacity may be due to the pigmentation, but we do not agree

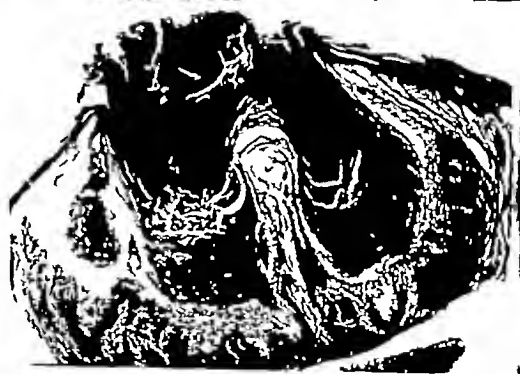


Fig 7 (top) Epidermal cancer—remark opacity of epidermal globe

Fig 8 (middle) Photomicrograph of an ordinary stained section of a lip papilloma

Fig 9 (bottom) Historadiograph of the same section. Notice the opacity of keratinous layer

with this supposition for in the historadiographs of melanic tumors we do not observe any particular opacity of pigmentation cells to  $\alpha$ -rays. Intercellular spaces may be seen with unbelievable richness in the Malpighi layer. Cytoplasm is granular and relatively opaque in regard to the nucleus, which is completely transparent. A highly opaque spot exists on the nucleus—the nucleolus. It is probable that the



Fig 5 (*above*) Historadiograph of epidermal section negative picture, as observed is directly under microscope  
Fig 6 (*below*) The same historadiograph but as a positive picture

leaves of aluminium (which we still employ) present many inconveniences, *e g*, frequent perforations in the course of rolling, and the utilization of cellophane was unsuccessful. The use of lithium windows (atomic number 3) is also to be tested.

The tube which we have made is of metal, with a water-cooled tungsten target, the air-cooled cathode is supported by a glass cylinder similar to Dauvilliers'. The difference consists of a cylindrical camera soldered to the body of the tube and hermetically closed behind, by a metallic disc, to avoid fluctuations during pumping, and the consecutive perforation of the filter. A large communication unites the camera and the body of the tube, the latter being mounted on an oil vapor diffusion pump.

The necessary vacuum is obtained about thirty minutes after starting, due to the high speed of exhaustion. The pumping stability is perfect, a special security sys-

tem cutting the current when the water fails.

The target of the tube is grounded. The exposure does not exceed 5 minutes with 5 kv potential and 80 ma intensity.

After exposure, the pumps are cooled for 30 minutes, and after admitting air, the camera is opened. The plate is developed with the "section" adhering to it. During the development it is generally easy to detach the section by rubbing it lightly. If it is thin enough, the section can be left adhering to the plate, as it does not hinder the examination of the image. It is sometimes difficult or even impossible to "unstick" it.

The window diaphragm of the camera has been specially studied with regard to the focal surface and distance of the preparation. The area, which when exposed corresponds to a circle of one centimeter diameter, is generally sufficient to cover all the section.

When the plate is dry, it is possible to examine it microscopically as if it were a histologic preparation.

*The Photographic Plates*—We make the plates ourselves, having tried numerous kinds, nearly all of them have annoying grains, even those sold as having none. The plates are made by Lippmann's technique for interferential photography, which is essentially delicate for small plates. We have made real progress by using celluloid supports which are easier to manipulate. The Gevaert Film Company, of Belgium, furnishes us with a special Lippmann film which gives great satisfaction.

The use of a film allows us to place the negative, after exposure, between two glass plates joined by Canada balsam, as in histologic preparations.

*Advantages of the Method*—Thanks to our method, we have been able to obtain radiographs of sections of animal tissues. We believe we are the first to accomplish this, Dauvilliers having worked on botanical sections only. The result has been made possible by very good emulsions and celluloid carriers, and above all by using a much softer x-ray beam (5 kv). As perfect a vacuum as possible is maintained in the

camera and there are practically no scattered radiations or absorption by gases. We have been able to reduce the time exposure considerably, from 2 hours (Dauvilliers) to 5 minutes. At the beginning of the research, exposures of 20 hours or more were necessary.

### RESULTS

The radiographic images thus obtained are sharp and clear. We foresee the possibility of much further progress with better vacuum conditions which demand some practice, it is necessary to use only a thin section and to have a perfect adherence between the section and the plate.

The image thus obtained is a negative one, and this presents the greatest obstacle to the histologist who examines it. The parts which are normally light on the colored preparation are often dark on the plate, and *vice versa*. This particularity necessitates a re-education of the eye, which we are persuaded can be quickly accomplished. In the difficult cases it is easy to obtain positive images by photomicrographs which are much simpler to interpret.

We have called the images thus obtained historadiographs, a name which exactly describes the classic microscopic structures, except for rare exceptions, and with some training, will be interpretable.

However, some new unforeseen aspects have been encountered in colored methods. Even with very thin sections considerable variation in opacity exists, some cellular structures absorbing x-rays more than others.

We cannot quote all the tissues examined, but taking human skin as an example, it is possible to state differences of absorption with regard to the various parts of the epidermic layer.

Peripheric cells of the horny layer are extremely opaque and with increasing depth the opacity gradually *lessens*, to arrive at a maximum at the level of the basal cells. This final opacity may be due to the pigmentation but we do not agree



Fig 7 (top) Epidermal cancer—remark opacity of epidermal globe

Fig 8 (middle) Photomicrograph of an ordinary stained section of a lip papilloma

Fig 9 (bottom) Historadiograph of the same section. Notice the opacity of keratinous layer

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substances of greater density found in the cell are condensed in this area

If we enter into the pathologic examination of the tissue, we shall see, for example, that keratinous cells of epidermic globes have a remarkable opacity and are much easier to discern than by any other method

Several other phenomena have been observed which will be explained in collaboration with histologists

#### CONCLUSIONS

The method enlarges the domain of medical histology. We believe that we are presenting here a new technic which will complete the coloration ones. We have great hopes in its future, for it introduces new elements in the physical and chemical nature of cellular constituents. Absorption zones correspond to regions of small atomic weight, and *vice versa*. As Dauvilliers has already emphasized, with very soft x-rays oxygen will be more absorbant than carbon, for example, and any trace of sulphur in the preparation will suffice to render it opaque.

This new process will make possible information on the density of cellular constituents. With the aid of a new chemical agent it will be easy to render opaque a particular cellular region and to study it better, as color does not play a part here, the range of useful agents being greater and at the same time the technic being

much more simple, the field of histochemistry will be enlarged.

It will be equally possible by this new method to recognize foreign substances introduced into the tissues, particularly the slight penetration by medicaments.

Methods of identification will find in this method a new and solid base.

#### SUMMARY

A new method to obtain radiographs of microscopic sections by use of very soft x-rays is presented, it is carried out *in vacuo*. Special photographic emulsions are utilized which allow greater enlargements. The images obtained, which are examined microscopically, have already shown special new aspects which will be of great importance in histologic examinations.

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# THE BIOLOGICAL MEASUREMENT OF GAMMA RAYS IN "EQUIVALENT ROENTGENS"

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**D**URING the past decade a number of attempts have been made to unify the methods of measuring x-rays and gamma rays. Since both types of radiation are used extensively in cancer therapy, it is important to be able to express their dosages in a common unit. Even while the unification work has been going on, the range of wave lengths available in the therapeutic portion of the electromagnetic spectrum has been greatly expanded, thus making unification still more important.

Since the international unit, the roentgen, has been satisfactory for measuring x-rays, it is natural that attempts should have been made to measure gamma rays in the same unit. Theoretically, this should be possible and the roentgen has been employed as the unit quantity of radiation in practically all unification attempts.

In general, two methods of measuring x-rays and gamma rays in the same unit have been employed. The first is direct and involves a procedure carried out in accordance with restrictions imposed by the definition of the roentgen.<sup>1</sup> The second is indirect and is carried out by comparing gamma-ray doses required to produce an effect on a test object, living or non-living, with x-ray doses of known roentgen value required to produce the same effect. In such a case, the gamma-ray dose is not expressed in roentgens, as such, but in what has aptly been called "equivalent roentgens" (Failla, 1933). An equivalent roentgen may be defined for gamma-ray work as

the quantity of gamma rays which will produce the same effect as one roentgen of x-rays, x-rays produced at voltages around 200 kv being implied. Hence, while the equivalent roentgen value is dependent upon the response of the test object being used and may vary, it has been hoped that some general agreement would be found among the values obtained with the various test objects and thus provide a means of measuring the two radiations in a common unit.

We shall employ the expression *roentgens of gamma rays* in this report, but it is always to be understood that equivalent roentgens are meant unless otherwise stated.

The direct method of measurement would undoubtedly be superior, providing satisfactory measurements could be made, but almost insurmountable difficulties have been encountered. Hence, both methods have been used and already the literature has commenced to accumulate (Table I). By examining Table I, it will be seen that the results are quite discordant.

With the accumulation of data on this subject, there has been a tendency on the part of the recent writers to adopt a set of standard conditions for measuring and expressing gamma-ray intensities in order that results obtained by various investigators may be compared. For this purpose, 1 cm distance from a point source and a filter of 0.5 mm of platinum have been used. Since these specifications have been satisfactory, we, likewise, will employ them and refer to them as standard conditions. The unit distance of 1 cm was adopted mainly because it satisfactorily combines convenience of manipulation and radiation economy, and the filter of 0.5 mm of platinum because it cuts out practically all of

<sup>1</sup> The roentgen as defined by the International Congress of Radiology, in 1928 may be given as follows: The unit of dose is that quantity of roentgen radiation which, when all of the secondary electrons are utilized and the wall effect of the chamber avoided, produces in 1 cc of atmospheric air at 0° C and 760 mm mercury pressure such a degree of conductivity that one electrostatic unit of charge is measured under saturation conditions. (See Reference 15.)



the beta particles while reducing the gamma-ray intensity only slightly<sup>2</sup>

Gamma-ray intensities, however, have been expressed in two ways. One gives them in r/min/gm while the other gives them in r/mg-hr. The differences lie only in the units of time and weight used to specify the exposure values. Since x-ray intensities are conventionally given in roentgens per minute, it seems more consistent to express gamma-ray intensities in the same way. Accordingly we shall use r/min/gm<sup>3</sup>.

The r/min/gm may be obtained for any given applicator or holder by finding two things: (1) the milliecurie-minutes required to produce a given effect when the particular applicator is used, and (2) the number of roentgens of x-rays required to produce the same effect. Then the (equivalent)

$$\text{r/min/gm} = \frac{r}{\text{mc-min}} \times 1000$$

<sup>2</sup> Filters of 0.9 mm of lead or 2 mm of brass may be considered equivalent to 0.5 mm of platinum in this respect.

<sup>3</sup> The r/mg-hr may be obtained at any time, however, by dividing the r/min/gm by 16/3.

The transition from ordinary gamma ray units (mc-min) to equivalent roentgens is made by means of a conversion factor which consists of the ratio of gamma-ray dose (in mc-min) to x-ray dose (in roentgens) required to produce the same effect on a given test object. The constant 1,000 merely reduces millicuries to curies and gives the measurements in terms of a gram of radium rather than a milligram.

Two attempts have been made to measure gamma rays directly (Failla, 1931 and Mayneord, 1934). Values obtained by these investigators working independently are in agreement when derived under the same conditions, but vary from around 36 to 86 r/min/gm, depending upon the position, location, and type of measuring instrument employed. They both found that it is practically impossible to take full account of the secondary electrons when gamma rays are used, as is required by the definition of the roentgen, thus making it doubtful whether gamma-ray quantities can be determined satisfactorily in roentgens by the direct method.

The indirect method of measurement appears to avoid some of the difficulties, at

TABLE I—THE MEASUREMENT OF GAMMA RAYS IN ROENTGENS

1 cm Distance from a Point Source, Filtration the Equivalent of 0.5 mm Pt

Name	Year	Reference	Test Object	Effect Meas	r/mg-hr	r/min/gm
Direct Method						
Failla and Henshaw	1931	3	ion chamber	ionization	2.16*	36*
Mayneord and Roberts	1934	19	ion. chamber	ionization	3.06*	51*
Indirect Method (Ionization)						
Glasser and Mautz	1930	8	ion chamber	ionization	7.4	123
Friedrich <i>et al</i>	1934	6	ion chamber	ionization	7.9-11.2	132-187
Jaeger	1934	16	ion chamber	ionization	7.35	122
Mayneord and Roberts	1934	19	ion chamber	ionization	8.9	148
Sievert	1934	27	ion chamber	ionization	7.55	126
Friedrich	1935	7	ion chamber	ionization	7.8	130
Murdock and Stahel	1935	20	ion chamber	ionization	8.1	135
Indirect Method (in Liquid)						
Taylor and Mohler	1935	28	CS <sub>2</sub>	ionization	6.9	115
Indirect Method (Biological)						
Braun	1930	1	<i>Ascaris</i> eggs	killing	5.3	88
Holthausen and Hamann	1932	14	skin	erythema	5.3	88
Neeff	1934	21	skin	erythema	5.7-6.3	95-105
Exner and Packard	1935	2	<i>Drosophila</i> eggs	killing	5	83
Henshaw and Francis	1936		<i>Drosophila</i> eggs	killing	5.4	90

\* See text for further information on these values

least in practice, and accordingly has been used more extensively (Table I). A number of measurements have been made with small thimble-type ionization chambers. The procedure has been as follows. The small chamber is calibrated in a beam of x-rays, the intensity of which has been measured with a standard chamber in accordance with the requirements of the roentgen. It then is placed in the gamma-ray beam and the measurement made. Presumably, therefore, since the chamber has been calibrated to give readings in roentgens, the gamma-ray readings should be in roentgens also. The results obtained by various investigators are shown in Table I and will be seen to vary as much as 35 per cent. Furthermore, the values obtained by the indirect method (122 to 187 r/min/gm) will be seen to be in a range quite apart from those obtained by the direct method (36 to 51 r/min/gm). The average difference is in the order of 300 per cent. From the work of Failla and collaborators (1933), it appears that the kind and thickness of material used in the construction of the small chambers have much to do with the amount of ionization detected when different wave lengths of radiation are used.

Because of the difficulties experienced in the physical measurements of gamma rays, both directly and indirectly, the biological measurements assume greater prominence.<sup>4</sup> Like the thimble-type chambers, living test objects may be used without regard to secondary radiation and thus give a measure of gamma rays in equivalent roentgens for conditions met with in practice. The biological work, however, is of two-fold importance. Not only does it give a measure of gamma rays in equivalent roentgens, but also information on the question of the relative biological effectiveness of different wave lengths of radiation.

If it is found, for example, that the gamma-ray value in roentgens is the same in every case, irrespective of the type of biological test object used, it will follow that the various wave lengths of radiation produce the same relative effect and that they manifest no selective action. On the other hand, if it is found that the gamma-ray value in roentgens is different when different test objects are used, it will follow that differential effects are produced by the different wave lengths of radiation and that some degree of selectivity is expressed.

Only a few intensity measurements of gamma rays have been made with living material, however, under conditions which can be compared. Gamma-ray sources are usually of a shape and distribution (tubes, cylinders, and plaques) which make the factors of distance and filtration difficult to estimate accurately, especially when the source has a dimension of more than 1 cm, and the distance from the source to the material is 1 cm, or less.

Biological measurements of gamma rays have been made by Braun (1930) using *Ascaris* eggs, and by Holthusen and Hamann (1932), and Neeff (1934) using human skin (erythema). While these investigators used distributed sources instead of a point source, Sievert (1934) has, for purposes of comparison, adjusted the values by rough calculation to the standard conditions mentioned above. Sievert's corrected values are shown in Table I where it will be seen that they range quite close together. This consistency, however, cannot have a very significant meaning in view of the rather uncertain corrections that were necessary.

Packard (1928) carried out a series of experiments under conditions that were reproducible and to some extent more clearly defined. He exposed the eggs of *Drosophila melanogaster* on the surface of a hard rubber cylinder. The cylinder was approximately 2 cm in diameter and contained glass radon tubes at the center surrounded with a small cylinder of lead, the wall thickness of which was 2 mm. Thus, with the radon tubes packed close together at

<sup>4</sup> Some of the first attempts to measure x-rays and gamma rays in the same unit were carried out with biological material (Frederich and Opitz, 1920; Lahm, 1925; Jona, 1926; Schneider 1926; Zuppinger, 1928). Certain of this early work has been reviewed by Glasser in 1929.

the center and the material arranged at the surface of the hard rubber cylinder, the position of the test material with respect to the source of radiation was quite uniform. With this arrangement Packard found 5,300 mc-min of gamma rays were required to produce the same effect (50 per cent killing) as 180 roentgens of x-rays. But, as will be brought out more clearly below (Fig 6), the factors of distance and filtration cannot be computed accurately.

Realizing the necessity of irradiating living test material under conditions still more like the adopted standard conditions if reliable comparisons were to be made, Failla, of this laboratory, developed a holder or applicator which met the standard conditions in practically every detail (described below). Packard and Exner became interested in such a holder in order that they might carry out Packard's experiments under more suitable conditions. Accordingly, a holder was made through the co-operative efforts of the Institute of Cancer Research and the Memorial Hospital, and experiments with *Drosophila* eggs have been carried out in both institutions. The results obtained by Packard with the new holder (spherical) have already been published (Exner and Packard, 1935). These investigators obtained a final value of 83.3 equivalent r/min/gm (5 r/mg-hr) for the standard conditions.

The experiments presented by Exner and Packard and those presented here were jointly planned for the purpose of testing the reproducibility of the equivalent r/min/gm value for gamma rays as determined with *Drosophila* eggs. Inasmuch as the same holder was used in both cases, the essential differences consisted of different laboratory environments (mainly temperature), different laboratory strains of *Drosophila*, and different radon bulbs. Under these circumstances, an agreement between the values of our respective experiments will tend to establish a reliable ratio (or conversion factor) between gamma-ray doses and x-ray doses for one kind of test object.

In addition to the work with the spheri-

cal holder, we have carried out experiments with the cylindrical holder used by Packard,<sup>5</sup> in 1928. Our experiments with the two holders were carried out in the same way and at the same time, thus making it possible to compare them directly.

Furthermore, we have used eggs of different ages. Eggs three hours older than those used for the experiments just mentioned are several times more resistant to radiation, a fact pointed out by us in 1933 and confirmed by Packard in 1935. The r/min/gm has been obtained with this material using the spherical holder. The results obtained will also be presented.

#### MATERIALS AND METHODS

The eggs of a wild-type strain of *Drosophila melanogaster* (Oregon strain) were used for all of the experiments to be reported here. The adult flies were cultured in bottles in the usual way on a molasses-cornmeal medium. Eggs were collected from actively laying flies which were usually four days old. Collection was accomplished by placing slides, on which the flies were to deposit the eggs, in clean dry bottles containing several hundred flies. The slides as used were covered with black filter paper moistened with yeast and banana juice. At the end of one hour, they were removed and examined to see whether the flies were laying actively. If there were not a large number of eggs present, the flies were put aside and not used. If there were, fresh slides were placed in the bottles and left for two hours. The eggs laid during this time were removed with a soft brush to small pieces of paper suitable for handling during treatment.

The one hour pre-laying period was a precaution to insure greater uniformity in age of eggs. If the flies were found to be laying actively, it was assumed (1) that most of the fertilized eggs which the female flies sometimes have a tendency to carry in the vagina for a period before laying, were fairly well eliminated, and (2) that the

<sup>5</sup> We wish to express our indebtedness to Dr Packard for the privilege of using this holder.

eggs were being deposited at a fairly uniform rate Packard used a somewhat different procedure for eliminating the older eggs He collected the eggs in the usual way without bothering about a pre-laying period, carried out his experiments during the early afternoon of one day, and left the material in moist chambers overnight at room temperature The next morning, when the eggs were around 20 hours old, he counted them, rejecting all those that had hatched He assumed that the first to hatch were older, more resistant to the radiation and, therefore, should not be considered along with the others Such procedure has not been satisfactory in our laboratory, however Packard points out that there are one or two and rarely more than five or six in a sample of 100 that hatch within 20 hours We, on the other hand, find that as many as 50 per cent may hatch during this period, depending upon the temperature of the room Since our laboratory is located in a hospital, our average temperature ( $22^{\circ}$  to  $26^{\circ}$  C) was higher than Packard's laboratory which is not in a hospital Thus, an explanation is offered for the differences observed In any case, it is clear that we could not follow the same procedure in eliminating older eggs

For our experiments, treatment began regularly 30 minutes after the end of the collection period when the younger material was used, and three and one-half hours after the end of the collection when the older material was used Practically every time an experiment was carried out with one of the gamma-ray applicators a similar experiment was done with x-rays, using a portion of the same collection of eggs and treated at the same time This was an attempt to prevent any differences in age, stage, rate of growth, etc., in different collections from affecting the gamma-ray results without affecting the x-ray results in the same way By this procedure, the x-ray results served as a base reference for the gamma-ray results obtained with the different applicators If it was found that the x-ray results were generally alike

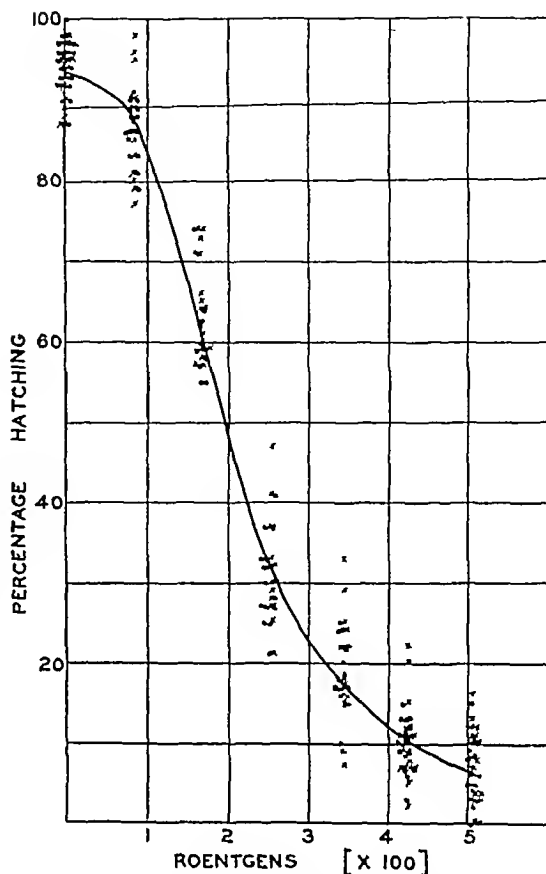


Fig 1 X-ray curve showing how percentage of eggs hatching varies with the dose of radiation administered

in the two cases, it is obvious that the two types of gamma-ray results could be compared directly

#### EXPERIMENTS WITH X-RAYS (EGGS ONE-HALF HOUR OLD)

The material treated with x-rays, as mentioned, was composed of portions of the samples collected for gamma-ray treatment The eggs were collected as described and removed with a soft brush to small rectangular strips of thin soft paper (drug store "kleenex") 2 mm in width and 8 mm long and moistened with tap water The eggs were spread evenly one layer thick in such a way that each paper contained well over 100 eggs These were placed in a tray made by gluing sheet celluloid 0.015 mm thick to an embroidery

the center and the material arranged at the surface of the hard rubber cylinder, the position of the test material with respect to the source of radiation was quite uniform. With this arrangement Packard found 5,300 mc-min of gamma rays were required to produce the same effect (50 per cent killing) as 180 roentgens of x-rays. But, as will be brought out more clearly below (Fig 6), the factors of distance and filtration cannot be computed accurately.

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trols, were put away in moist chambers to await hatching. After 48 hours, the eggs were counted and the percentage hatched was determined.

The results obtained are shown graphically in Figure 1, without corrections or modifications. The points marked (x) were obtained in tests carried out in connection with the cylindrical applicator, while those marked (•) were carried out in connection with those done with the spherical applicator. In all, 41 x-ray experiments were performed, around 300 samples were observed and more than 50,000 eggs were counted.

#### SPHERICAL APPLICATOR EXPERIMENTS (EGGS ONE-HALF HOUR OLD)

The details of the spherical holder are shown in Figure 2. As will be seen, the main portion of this is composed of a bakelite sphere ( $D_1$ ) 18.6 mm in diameter with a hole drilled into it to a proper depth and rounded at the bottom. Into this hole is fitted a bakelite plug ( $D_2$ ) which supports a spherical platinum filter ( $C_1$  and  $C_2$ ) and a radon bulb (A). The device is constructed in such a way that the bulb and platinum sphere are held precisely at the center when the plug is pushed all the way in. The platinum filter consists of two sections,  $C_1$  and  $C_2$ , machined out of solid bar in such a way that  $C_1$  fits into  $C_2$  making a closed hollow sphere with a wall thickness of 5 mm and an outside diameter of 9.2 mm. Inasmuch as the inside diameter was 8.2 mm, and since the outside diameter of the radon bulb (A) was 3.5 mm, some provision had to be made to hold the bulb at the center. This was done by moulding and drilling out a piece of paraffin (B) to proper dimensions.

Thus, since the radiation source was spherical in shape and placed at the center of a spherical holder, it provided very nearly an effective point source, and since the filter was uniform in thickness and was arranged with spherical symmetry around an effective point source of radiation at the center, a uniform radiation was provided at every point on the surface of the holder.

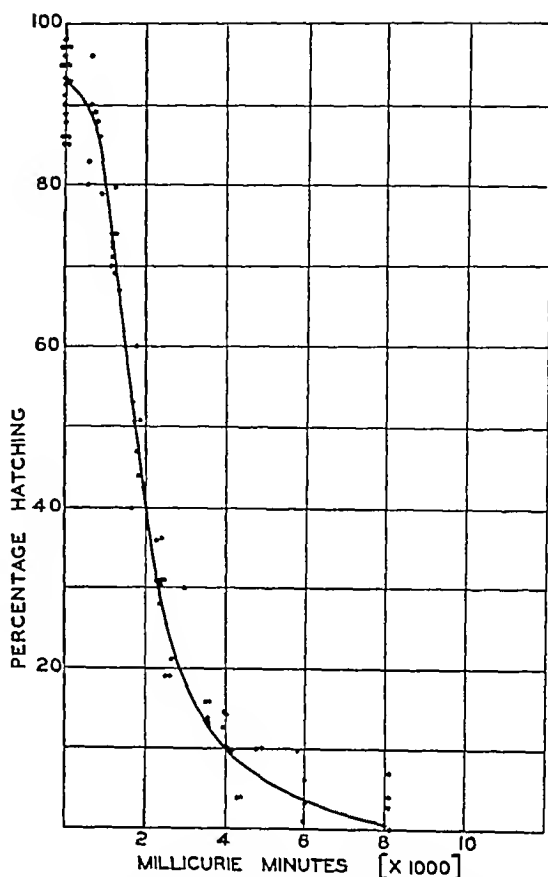


Fig 3 Gamma ray curve obtained with the spherical applicator, showing how percentage of eggs hatching varies with the dose of radiation administered

The platinum acted to stop all of the beta rays and the bakelite acted to stop the secondary radiation generated by the platinum. As mentioned, the outside diameter of the bakelite sphere was 18.6 mm, making the distance from the center 9.3 mm<sup>6</sup>. Adding 0.1 mm for the thickness of paper used to support the eggs and half the thickness of the eggs, the distance from the effective point source to the central region of the test material was 9.4 mm.

The bakelite sections  $D_1$  and  $D_2$  were supported on the ends of "swab sticks"

<sup>6</sup> It will be noticed that the dimension of the outside diameter given here and the one given by Exner and Packard differs by 0.1 mm. This is because the larger bakelite section used by Exner and Packard was not available when these experiments were carried out. A second section was therefore made from the same stock material the diameter differing by the amount indicated. The other parts of the holder were the same as those used by Exner and Packard.

hoop. The tray then was placed at a point 50 cm distance from the center of the target of the x-ray tube so that nothing

small thimble-type ionization chamber with an inside diameter of 1.52 cm and a wall thickness of 1.4 mm. Previous to use,

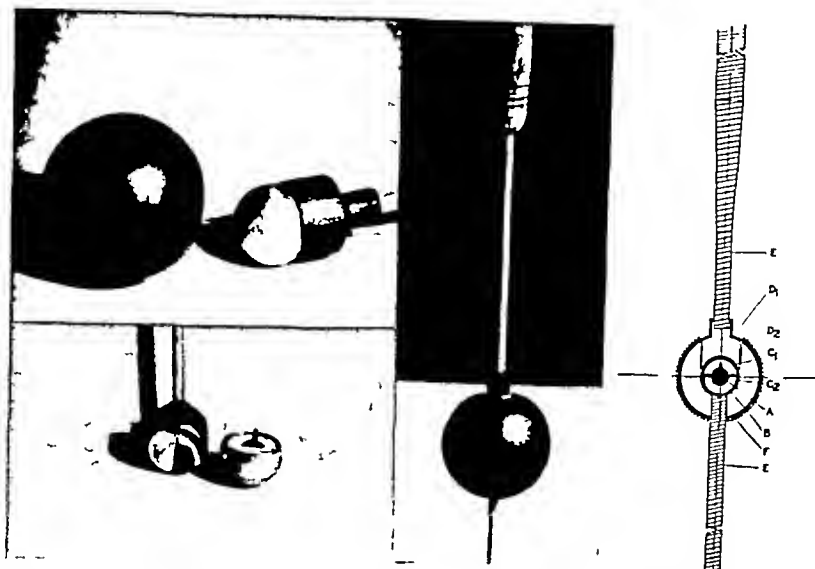


Fig. 2. Photographs and figure showing details of the spherical applicator (A) radon bulb, (B) paraffin (C) and (C) sections of hollow platinum sphere, (D<sub>1</sub>) and (D<sub>2</sub>) sections of bakelite sphere, (E) swab stick support (F) test material

was beneath the test material (within 20 inches) except the 0.015 mm of celluloid. Thus back-scattered radiation was reduced to a minimum.

The irradiation conditions were as follows:

200	kV
169	pV
30	ma
50	cm dist to material
34	cm dist to filter
8 mm Cu	} filter
1.15 mm Cellu	

The intensity was kept uniform by means of an ionization chamber-galvanometer arrangement. An ionization chamber was placed in a fixed relation to the x-ray tube (not in the beam used for treatment) and connected to a galvanometer near the control panel. Thus, by keeping the galvanometer reading constant, it was certain that the intensity of radiation emitted by the tube remained constant. Having selected an intensity of radiation to work with, this was carefully measured in roentgens per minute at the point at which the test material was placed. This was done with a

the chamber was calibrated against a standard open-type ionization chamber.

By keeping the galvanometer reading constant, calibrations were made from time to time during the course of the work which covered a period of several months in order to detect any drift in the galvanometer or other parts. The values obtained were as follows:

4/5/35	43.3 r/min
4/30/35	42.3
6/20/35	41.5
9/17/35	41.2
10/1/35	41.5
11/1/35	43.5
11/29/35	42.8

Av 42.3 ± 0.3 A D

Despite all the precautions which were taken, a small amount of variation occurred in the measurements as indicated, but since this was small the average value will be taken as the intensity used.

Treatment was carried out by exposing the organisms to the direct beam of the rays for different periods of time. Samples were removed at two-minute intervals. The irradiated samples, together with con-

is shown in Figure 4. It was made up of a solid hard rubber rod (D) into which was sunk a lead cylinder at the center. The in-

500 mc. Different numbers of tubes (bare) were used, depending on the strength of those available. Usually one or two were

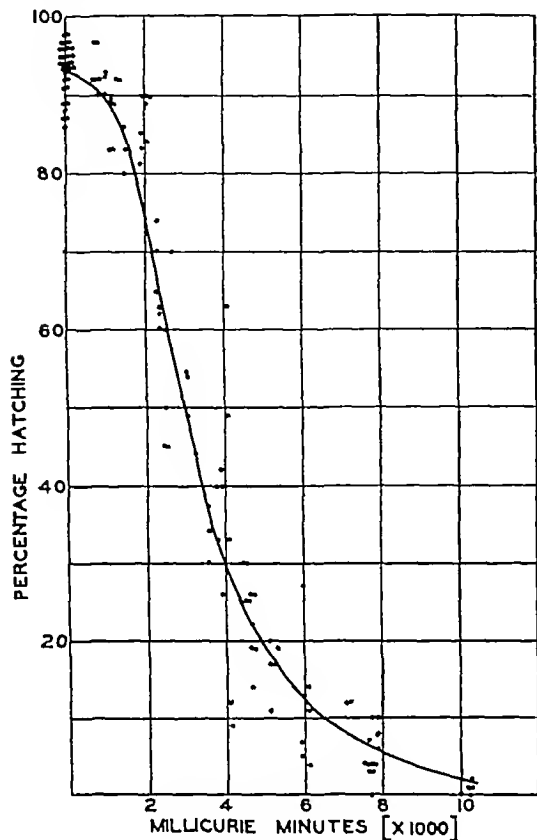


Fig 5

Fig 5 Gamma ray curve obtained with the cylindrical applicator, showing how percentage of eggs hatching varies with the dose of radiation administered

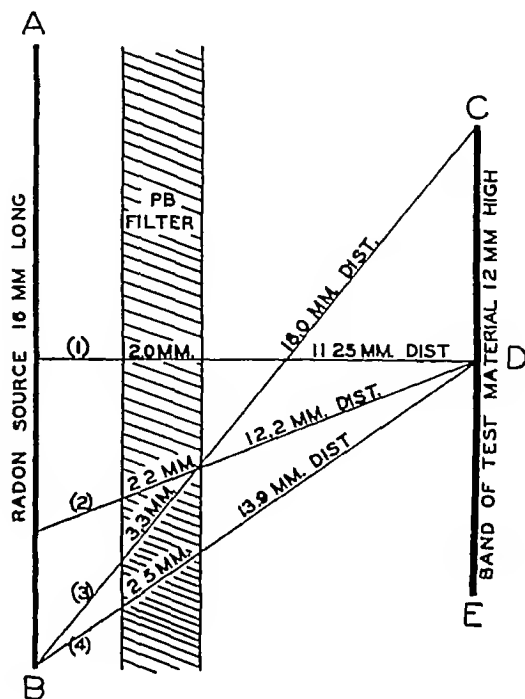


Fig 6

Fig 6 Diagram showing details in regard to distance and filtration when the cylindrical applicator is used

side diameter of the lead cylinder was 2.2 mm and the wall thickness was 2 mm. The thickness of the hard rubber surrounding the lead cylinder was 8.05 mm, making the distance from the center to the surface 11.15 mm. The hard rubber cylinder was firmly attached to a dowel rod (E) about 18 inches long, which was sunk a short distance into the end opposite to the lead. With this the cylinder was conveniently and safely handled even though it contained radon. During treatment the cylinder was suspended from the ceiling as in the case of the sphere.

For the experiments performed, we used a radon source (A) at the center of the cylinder having an initial strength around

used, but the number reached as high as seven. Since the opening in the center of the holder was larger than the combined diameter of the radon tubes, the tubes (or tube) were carefully centered by placing them together in a snug bundle inside a paper tube (B), the wall thickness of which was adjusted in each case to accommodate the number of tubes used. The radon tubes were made secure at one end of the paper tube (B), the wall thickness of which was adjusted in each case to accommodate the number of tubes used. The radon tubes were made secure at one end of the paper tube which was made long enough to protrude beyond the end of the holder. Thus, by handling the paper tube



(E, Fig 2) One of these was sunk into a dowel rod so that the whole could be handled at a distance. With this arrange-

When deterioration had been taken into account, the differences between the earlier and later measurements were insignificant.

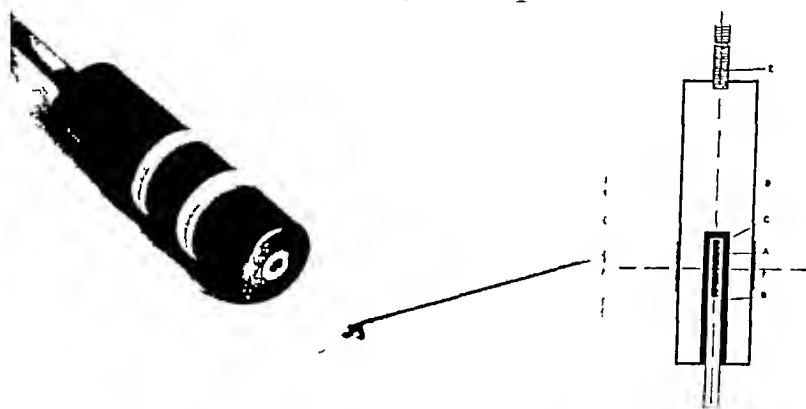


Fig 4 Photograph and figure showing details of the cylindrical applicator (A) radon tube, (B) paper tube, (C) lead filter (D) hard rubber cylinder, (E) dowel rod support, (F) test material

ment the sphere containing eggs and the plug containing radon were easily and safely handled. During treatment the applicator was suspended from the ceiling by a string attached to the dowel rod. It was arranged in a large room so that the nearest table or article was at least four feet away, thus rendering the back-scattered radiation coming from secondary radiators outside the holder quite insignificant.

For the experiments carried out with the spherical applicator, the eggs were collected and handled as described in case of the x-ray experiments, except that they were placed on pieces of "kleenex" which were lens-shaped. When these pieces of paper were well wetted and placed on the surface of the sphere, they clung to the surface and conformed to its curvature, thus making the distance uniform.

The initial strength of the radon bulb as used was usually around 500 mc. Intensity measurements were made according to the usual procedure employed at the hospital, except that an additional measurement was made in a few cases when the bulb was around 50 mc, since the strength of our radium standard was around 50 mg.

Treatments were carried out as follows. The egg samples were placed on the surface of the sphere and the exposure started by inserting the plug which supported the platinum sphere and radon bulb. The exposure was stopped by removing the plug. At regular intervals, usually two minutes, two or three samples were removed until the series was finished. The interval of treatment was determined by the intensity of the source, and since the dose administered depended entirely on this, it was determined with all possible precision. At the end of treatment the irradiated samples, together with controls, were put away in moist chambers for 48 hours to await hatching. At the end of this time the percentage hatching was determined and recorded. Twenty-two complete experiments were carried out, about 175 samples were observed, and more than 25,000 eggs were counted in connection with the spherical applicator work. The results are shown graphically in Figure 3 without corrections or adjustments.

#### CYLINDRICAL APPLICATOR EXPERIMENTS (EGGS ONE-HALF HOUR OLD)

The applicator used by Packard in 1928

The results are shown in Figures 7 and 8. Figure 7 is for x-rays. Curve 1 of this figure is for eggs one-half hour old and is copied from Figure 1. The experimental points are for eggs three and one-half hours old, and Curve 2 is the best curve that could be drawn through them. Figure 8 is for corresponding gamma-ray experiments.

Referring to Figure 7, the difference in position of Curves 1 and 2 represents the difference in susceptibility of the eggs of the different ages. For example, 197 roentgens were sufficient to kill 50 per cent of the younger eggs, whereas, 1,130 roentgens were required to kill the same percentage of older eggs. Referring to Figure 8, it will be seen, likewise, that 1,800 and 10,000 mc-min, respectively, were required to kill half of the eggs for the two ages. The relative values for different degrees of effect are given in Table II.

Since the corresponding ratios in the two cases are so nearly the same, it is clear that the organisms respond in essentially the same way to the different radiations at the two stages, and that the older material is roughly six times more resistant than the younger.

Curve 3, shown in both Figures 7 and 8, has been drawn similar to Curve 1 in each case, with the 50 per cent point coinciding with that of Curve 2. It will be seen at once that Curve 3 does not fit the experi-

mental points except in the neighborhood of 50 per cent. The higher values in each case lie above Curve 3, whereas, the lower values lie below it.

Packard (1935), dealing with the radiosensitivity of eggs of different ages, found as we did (Henshaw and Henshaw, 1933) that the radiosensitivity of the eggs varies markedly with changes in age. He found, however, that the shape of the curves for the different ages of material was similar, and questioned the validity of our findings. We wish to point out and emphasize that for this work Packard digressed from his standard procedure and used eggs collected during one-half hour rather than during two hours as usual for his work and as we have done. Thus, in view of the fact that the radiosensitivity varies so markedly with age and that the length of the collection period in the two cases was very different, the two sets of results cannot be compared.

#### DISCUSSION OF RESULTS

From Figures 1, 3, and 5, which show results for eggs one-half hour old after the end of collection, it will be seen that the fertility of the controls (*i.e.*, the percentage hatching) ranges generally above 90 per cent. In a few cases the fertility dropped below 85 per cent but the results obtained with such material were discarded. The value of 93 per cent was taken, therefore,

TABLE II—DOSES REQUIRED TO PRODUCE THE SAME EFFECT

Percentage Effect	X rays (r)			Gamma rays (mc. min.)		
	Eggs one half hr old (A)	Eggs three and one-half hr old (B)	Ratio (B)/(A)	Eggs one-half hr old (C)	Eggs three and one-half hr old (D)	Ratio (D)/(C)
75	125	960	7.7	1,150	8,200	7.1
70	140	995	7.1	1,300	8,650	6.7
65	155	1,035	6.7	1,450	9,000	6.2
60	170	1,065	6.3	1,600	9,350	5.9
55	184	1,100	6.0	1,760	9,700	5.5
50	197	1,130	5.7	1,900	10,000	5.3
45	210	1,160	5.5	2,070	10,300	5.0
40	224	1,190	5.3	2,200	10,500	4.8
35	241	1,220	5.0	2,400	10,800	4.5
30	264	1,250	4.7	2,560	11,000	4.3
25	291	1,285	4.4	2,800	11,400	4.1
	Average		6.14	Average		5.86

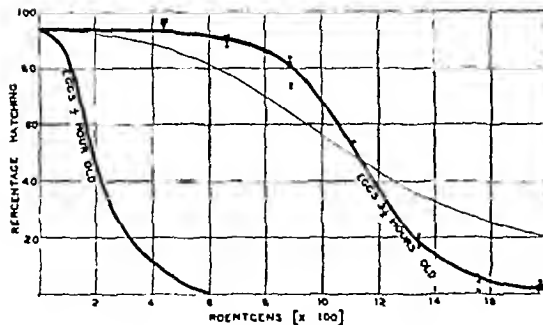


Fig 7

Fig 7 Curve comparing the radiosensitivity of eggs of different ages to  $\gamma$  rays. Curve (1) is for eggs one half hour old after the end of collection, and Curve (2) is for eggs three and one half hours old after the same time. Curve (3) is drawn similar to Curve (1) with the 50 per cent point coinciding with the 50 per cent point of Curve 2.

Fig 8 Curve comparing the radiosensitivity of eggs of different ages to gamma rays. Curve (1) is for eggs one half hour old after the end of collection, and Curve (2) is for eggs three and one half hours old after the same time. Curve (3) is drawn similar to Curve (1) with the 50 per cent point coinciding with the 50 per cent point of Curve (2).

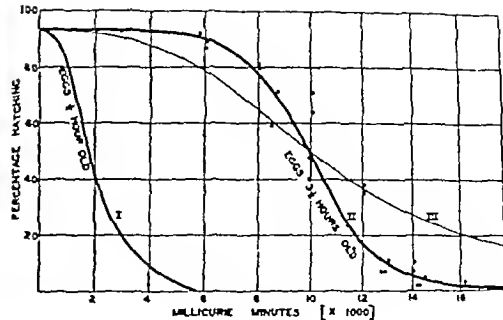


Fig 8

it was possible to insert and remove the radiation source from the holder with ease.

The eggs were collected as described above and arranged on small rectangular strips of moist "kleenex." The samples thus prepared were then placed on the surface of the cylinder directly over the place where the radon tubes would be when the paper tube was pushed in as far as it would go. As many as 20 samples with as many as a hundred eggs or more could be placed on the available area. The thickness of the paper and half the thickness of the eggs was about 0.1 mm, making the distance from the center of the cylinder to the center of the eggs 11.25 mm.

Treatment was carried out by inserting the radon tubes for definite periods of time, the timing taking place as in case of the spherical holder. At the end of treatment the irradiated samples, together with controls, were put away in moist chambers to await hatching. After 48 hours the samples were examined and the percentage hatching was determined in each case. The results with no corrections or adjustments are shown graphically in Figure 2. This represents 45 complete experiments, about 350 samples observed and approximately 50,000 eggs counted.

Some of the difficulties arising when calculating dosages administered with this type of applicator can be realized by a

study of Figure 6. The distance and thickness of filter, etc., are accurately known for the radiation which travels along line (1), but only part of the radiation follows such a course. Some of it travels along lines (2), (3), and (4), etc., making the integrated dose delivered to the sample of test material as a whole practically impossible to compute.

#### EXPERIMENTS WITH EGGS THREE AND ONE-HALF HOURS OLD

For the experiments thus far described, only eggs one-half hour old after the end of the collection period were used. As pointed out in the introduction, these same organisms when three hours older are several times more resistant to radiation. Although only slightly different in age, they are vastly different in stage of development and response to radiation. Hence it is of interest to determine whether such organisms give the same equivalent  $r/\text{min}/\text{gm}$  for gamma rays as the younger material.

This was investigated with the sphere applicator and precisely the same procedure was used as before except that an interval of three and one-half hours was allowed to intervene between the end of the collection period and the time when treatment began.

TABLE IV—DOSES REQUIRED TO PRODUCE 50 PER CENT HATCHING

	Packard	Henshaw
X-rays	190 r 180 r (1928)	205 r
Gamma rays (cylinder)	5,300 mc.-min (1928)	3,100 mc.-min
Ratio $\frac{(\text{mc.-min})}{(\text{r})}$	29.7	14.95

for this holder, so that Packard's findings (1928) and ours given here may best be compared by referring to the actual values obtained

In our presentation thus far, it has not been necessary to correct the results for fertility. Here it becomes so, however, because Packard's results are thus corrected. Accordingly, in Figure 9 the curves of Figures 1, 3, and 5 have been adjusted by making the fertility of the controls appear as 100 per cent. This was done by dividing each experimental point along the curve by 93. Such treatment changes the actual values along the curves slightly but does not alter the relationship of the curves to each other in any way. Since in Table III, the curves have been shown to be practically similar, we may take the dosage values required to produce 50 per cent hatching as representative of the relationship of the curves, such values are shown in Table IV. Similar values taken from Packard's papers are shown also.

Before comparing the values, however, certain irregularities must be considered. From Figure 9, we found the number of roentgens of  $\gamma$ -rays required to kill half the eggs in a sample to be 205 r, whereas, Packard found it to be 190 (180 r, in 1928), a difference of about 8 per cent. This is no doubt due to the fact that the material we used was younger than that used by Packard. His was one-hour old after the end of a two-hour collection period, while ours was only one-half hour old. As indicated above, both Packard and we have shown previously that the younger material is more resistant to radiation. We chose to

use the younger material so that the procedure would be in accordance with other work upon which these findings have a

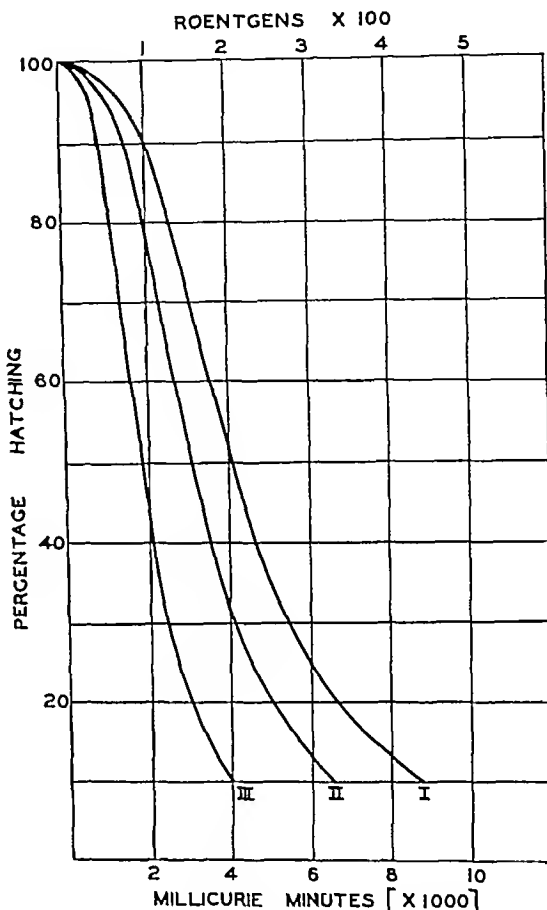


Fig 9 Curves from Figures 1, 3, and 5 corrected so that the fertility of the controls is 100 per cent. Curve (1) is for  $\gamma$ -ray results, Curve (2) is for cylindrical applicator results and Curve (3) is for spherical applicator results

bearing. The difference in susceptibility at the stages used, however, should not interfere with the determination of the  $\text{r/min/gm}$ , that is, unless there is a differential effect for these slightly different ages, which apparently is not the case in view of the findings with material three and one-half hours old. In this way the difference between Packard's  $\gamma$ -ray value and ours may be accounted for.

Since the same kind of material was used by Packard and by us in much the same way with the cylindrical applicator, it

TABLE III —DOSES OF RADIATION REQUIRED TO PRODUCE THE SAME EFFECT

Per-centage Effect	Roent-gens of $\gamma$ -rays (A)	mc-min (sphere) (B)	mc min (cylinder) (C)	Ratio (A) (B)	Ratio (A) (C)
75	125	1,150	2 000	109	062
70	140	1,300	2 200	108	064
65	155	1 450	2 350	107	066
60	170	1 600	2 550	106	065
55	184	1 760	2 800	104	067
50	197	1 900	3,000	104	066
45	210	2 070	3,250	102	065
40	224	2,200	3,550	102	063
35	241	2 400	3 900	100	062
30	264	2,560	4,300	103	061
25	291	2,800	4 750	104	061
	Average			1045	0635

as the fertility of the controls for each group and is the point through which the curves are drawn in the figures

Analysis of the three sets of data was carried out as follows. First, the best curves were fitted to the experimental points as shown in the figures. Ratios of  $\gamma$ -ray dose to gamma-ray dose (spherical holder) and  $\gamma$ -ray dose to gamma-ray dose (cylindrical holder) were then obtained for corresponding levels of effect along the curves. These are shown in Table III.

It will be seen that the central more dependable range of the curves bear practically a constant relation to each other. This indicates that the curves are similar in shape and creates the presumption that the same kind of effect is produced, irrespective of the type of radiation or the type of holder used.

Considering the spherical holder results only for the moment and following the procedure outlined in the introduction, the equivalent roentgen value for gamma rays may be obtained from the average value at the bottom of next to the last column in Table III, 0.1045. This is the conversion ratio mentioned previously and needs only to be multiplied by 1,000 to give the  $r/min/gm$ . It, accordingly, becomes 104.5. This, however, is for a distance of 9.4 mm (see description of the spherical applicator and of the conditions used). Correcting this for 1 cm distance by means of the inverse square law the value becomes 92.3.

Deducting, as did Exner and Packard, 1 per cent for the absorption in bakelite,<sup>7</sup> we have as a final value 91.4  $r/min/gm$  to be compared with the value of 83.3 obtained by Exner and Packard.

Exner and Packard used a somewhat different procedure in analyzing their results. They obtained a conversion factor for each gamma-ray exposure made, by referring each gamma-ray effect value (percentage hatching) to the  $\gamma$ -ray curve and finding the  $\gamma$ -ray dose required to produce the same effect. Beyond this their procedure was the same as ours. The essential difference in the two cases was that they computed the equivalent  $r/min/gm$  (in their case,  $r/mg-hr$ ) for each gamma ray value obtained experimentally, whereas we computed it only once from curves fitted to the experimental points.

When our results are analyzed in accordance with the method used by Exner and Packard, a final value of 89.7  $r/min/gm$  is derived, which differs from our other value, 91.4, by less than 2 per cent. Since there is little choice between the values obtained by the two methods, we shall adopt the intermediate even figure of 90 as the equivalent  $r/min/gm$  of gamma rays obtained at 1 cm distance from a point source with *Drosophila* eggs. This differs from Exner and Packard's value by 8 per cent, a reasonably close agreement considering the possible sources of error in such an experiment. We have chosen to present in detail the graphic method of analyzing the results because it displays the results to better advantage.

The findings obtained with the cylindrical holder will now be considered. As indicated above, the arrangement of this holder (Fig. 6) makes it practically impossible to reduce the values obtained to the standard conditions. There is little point, therefore, in determining the  $r/min/gm$ .

<sup>7</sup> Exner and Packard have determined the composition of the bakelite used in the construction of this holder and have discussed rather thoroughly the influence of this material on the beam of gamma rays. Since we are chiefly concerned with reproducibility aside from physical corrections we have made the same adjustment here.

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would be expected that generally the same results would be obtained. This was not the case, for, as shown in Table IV, Packard found 5,300 millicurie-minutes required to produce 50 per cent hatching, whereas, we found 3,100. Taking into account the difference in radiosensitivity of the materials used by determining ratios (Table IV), Packard found about twice as much radiation required with the cylinder as we did.

In conclusion, therefore, it appears that our results and Packard's obtained with the spherical applicator are in reasonable agreement, while those obtained with the cylindrical applicator are not. In view of the fact, however, that our experiments with the sphere and cylinder were carried out at the same time on portions of the same material and at a time when the influence of the age factor in *Drosophila* eggs was more fully appreciated, our results with the two holders are undoubtedly more dependable. Based on our results, the difference in effectiveness of the two holders is given by the ratio of dose which we found to produce the same effect in the two cases. Such a ratio is obtainable from the curves in Figure 9 or from the curves in Figures 3 and 5, and comes out to be approximately 1.6. This means that a given quantity of gamma rays will have about 1.6 times more effect when used in the spherical holder than when used in the cylindrical holder.

#### SUMMARY

The problem of unifying the methods of measuring x-rays and gamma rays has been reviewed and discussed. The results thus far available, unfortunately, are inconclusive. The physical measurements vary among themselves and the biological measurements are uncertain because of the conditions under which they were carried out.

In the present case, an attempt has been made to use a biological test object under conditions which would permit the value obtained to be expressed with some degree of dependability for the standard condi-

tions of 1 cm distance from an effective point source of radiation. Through the co-operation of the Memorial Hospital and the Institute of Cancer Research, a special applicator, approaching ideal conditions, was constructed for the work and similar experiments with *Drosophila* eggs have been carried out in both institutions.

In this laboratory, an equivalent roentgen value for gamma rays of 90 r/min/gm was obtained for the standard conditions, using eggs one-half hour old after the end of a two-hour collection period, and also using eggs three and one-half hours old which are approximately six times more resistant to the radiations. While, in these two cases, the organisms were widely different in susceptibility, they respond to the different radiations in relatively the same way, indicating no differential effect due to wave length.

The value of 90 r/min/gm compares favorably from the standpoint of reproducibility with the value of 83.3 obtained by Exner and Packard.

*Acknowledgments*—The writers wish to express their appreciation to Dr. G. Failla, who planned the special holder used and who offered invaluable advice throughout the course of the work, to Dr. Exner and Dr. Packard for their co-operation, and to Dr. Morton Schweitzer for assistance in analyzing the data obtained.

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and purulent pleurisy, and one with tuberculosis

Holt (9) stated that pneumothorax complicating tuberculosis is rare in patients under three years of age. Griffith (10) also stated that it is rare in early life, but he described it as following pneumonia, whooping cough, measles, diphtheria, emphysema, and in connection with an empyema or abscess of the lung that has burst through the pleura, or resulting from an injury due to a foreign body in the lung.

Garrod, Batten, and Thursfield (11) pointed out that the condition is usually a complication of pulmonary disease, or is caused by trauma or puncture of the lung by an exploratory needle. None of these authors refer to pneumothorax as occurring at birth or being caused by congenital conditions.

#### A REVIEW OF REPORTED CASES

A careful search of the literature disclosed only 22 cases in which the symptoms of pneumothorax were probably present from birth and in which the condition may be regarded as congenital.

In 1878, Ruge (12) reported the occurrence of pneumothorax in a newborn male child. Birth was by breech presentation, and the infant was delivered feet first, but delivery of the arms and head was not difficult. He was moderately asphyxiated when born, but cried considerably during the night. The following morning, he suddenly became cyanotic, and died shortly afterward.

At autopsy, when the left half of the thorax was opened, air rushed out. The heart was displaced to the right. The left lung was pressed against the spinal column. When placed in water, it sank but showed some small areas containing air. There was a small emphysematous area, and the pleura showed an irregular tear about 3 cm long. There was some free blood in the pleural cavity. The right lung was normal.

Ruge was of the opinion that, owing to premature respiration and inhalation of slime, meconium, and vernix caseosa before expulsion of the child, the respiratory pas-

sages were blocked, at least on the left side, and that, following more active respiration and crying, a circumscribed alveolar, later interstitial emphysema developed resulting in a rupture of the pleura. He did not attribute the cause of the condition to the method of delivery.

In 1917, Scheltema (13) reported the occurrence of pneumothorax in a child of seven weeks, with symptoms noted from birth. The child was born asphyxiated after normal labor. The mother said that in breathing the child moved its sides, suggesting exaggerated inspiratory retraction in the lowermost portion of the thorax. This sign was found to be bilateral and appeared only in the lowermost portion of the thorax, more on the left than on the right side. Respiration was somewhat accelerated, but the child presented a normal, well-nourished appearance. On crying, slight cyanosis appeared.

On percussion, a somewhat muffled sound with a tympanic note was heard in front and behind on the left side. On the right side, anteriorly, distinct dullness began below the clavicle, bounded externally by the nipple on the right side and by the sternum on the left. The apex beat could not be felt at the usual site. As a weak apex beat could be felt on the right side and cardiac dullness was not present on the left side, the heart was presumably displaced to the right. On the right side, the usual puerile breathing was heard, on the left side, the breath sounds were distant.

The symptoms pointed to the absence of the lung in the left half of the thorax and to a considerable displacement of the heart, with the mediastinum, to the right. This assumption was confirmed by the roentgen observations and transillumination at that time and three months later.

The most plausible explanation for the condition would seem to be aplasia of the lung, with an open communication between the pleuraless thoracic cavity and the bronchus. Diaphragmatic hernia could be excluded. The reason for the absence of fluid was not clear, but the condition could be clinically defined as pneumothorax.



# PNEUMOTHORAX IN THE NEWBORN

REVIEW OF LITERATURE AND REPORT OF SEVEN CASES

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IN April, 1933, I presented this subject before the Philadelphia Roentgen Ray Society, but it was not submitted for publication at that time. It seemed incredible that so many cases—seven—should be encountered by us in a period of four years, when a study of the literature revealed only an occasional single case report by other authors. Publication was further discouraged by the experience of at least one member of the Society, who had met with somewhat similar appearances, which he thought were due to a fold of skin, produced by pressure of the upper arm against the side of the chest, causing a shadow resembling pneumothorax. Repeated attempts, however, were made by us to produce this appearance by folding the skin in various areas on the chest and fixing the folds with adhesive plaster, but we were unable to obtain shadows which simulated those of any of our cases. Pfahler (1) had repeatedly insisted, after careful study of our films, that the appearances were unquestionably due to pneumothorax. I, therefore, wish to present seven cases of pneumothorax in the newborn, in addition to the cases reported by other authors, with a general review of the literature bearing on this subject.

Our cases were, without exception, diagnosed by the x-ray examination alone, and were discovered during the years when x-ray study of the chest in the newborn was almost a routine procedure. It is, therefore, evident that more of these cases would be found if more infants were subjected to an x-ray examination of the chest soon after birth.

A review of the literature in all languages indexed at the New York medical libraries indicates that congenital pneumothorax is an extremely rare condition, reports of only five cases having been reported up to 1930,

and only a total of 22 cases up to the present writing.

Knowledge of pneumothorax in general dates back to 1803, when Itard named the condition and recognized its relation to tuberculosis.

Lannec, in 1819, first described pneumothorax as a clinical entity, and was perhaps the first to diagnose the condition during life. He described the causes, symptoms, and physical signs, and also gave the "succussion splash" its correct interpretation. The significance of this splashing sound had not heretofore been understood, its presence was thought to indicate a moderate amount of pus in the chest, while its absence was interpreted as indicating a chest filled with pus. When pneumothorax was identified as a clinical entity, the meaning of the succussion splash became clear—a sign of the presence of fluid associated with air.

Emerson, in 1903, published an elaborate treatise on the disease, reviewed the literature, and reported 48 cases from the Johns Hopkins Hospital. Not a single case of pneumothorax in the newborn was included.

## PNEUMOTHORAX IN YOUNG CHILDREN

Pneumothorax occurs most frequently between the ages of 20 and 30 years. West (2) found that in 98 cases only six occurred before the age of 15 or after 40.

The condition is rare in persons under three years of age. West reported only one case in a patient so young. However, Moncrieff (3), Lees (4), Bashinski (5), Sanderson (6), Severre (7), and Variot (8) reported a total of eight cases in children under three years of age. Five of these were associated with pneumonia, one with scrofula, one with multiple lung abscesses.



Fig 3

Fig 3 Case 2 Showing partial collapse of right lung with pneumothorax in the outer third of the right chest (eight days old)

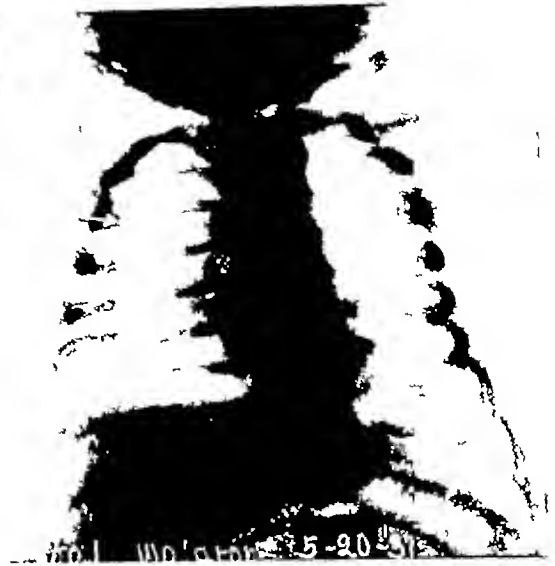


Fig 4

Fig 4 Case 3 Showing a small area of pneumothorax in the lateral aspect of the right pleural cavity (twelve days old)

collapsed, and 18 c c of air was again withdrawn. Shortly afterward, the child developed stridor, retraction of the thorax, and cyanosis. Oxygen was administered. X-ray films taken on the following day showed the left lung in apposition with the wall of the chest except along the lower border. The heart was in practically normal position, and the general condition of the child was satisfactory.

Flipse suggested that the cause of the stridor was collapse of the epiglottis, which the infant probably had at birth, and which obstructed the larynx. Inspiratory efforts may have ruptured an alveolus.

Stein (16) reported a case in 1930, of a boy who was first seen at the age of one week, because of vomiting and inability to gain weight. The mother was normal, but the patient was her first child and the delivery had been instrumental. So far as the history could be obtained, there had been no cyanosis or dyspnea at birth.

Physical examination at the age of one week showed a normal child except for the observations on the chest. Respiratory symptoms and cyanosis were absent. There was tympany over the entire right side of the chest, and voice and breath sounds were

absent on this side. The heart was displaced to the left, the right border being at the midsternal line.

Fluoroscopic examination showed the entire right side of the chest to be filled with air, the heart pushed over to the left, and what appeared to be the right lung situated at the root. A barium meal was given to rule out diaphragmatic hernia and eventration. It showed the stomach below the diaphragm on the left side and corroborated the previous observations.

At two years, the child was physically small for his age, and showed the characteristic pigeon-like deformity of the chest. He had had several attacks of bronchitis without undue consequences. At no time had he suffered from attacks of cyanosis or dyspnea. Fluoroscopy had been performed many times during his two years of life, with no change in the picture. At no time had there been any apparent absorption of the air. Possible etiologic factors had not become evident. The tuberculin reaction had been negative up to 5 mg. A bronchial fistula, however, could not be eliminated as contribution to the phenomenon. There had never been any evidence of infection.

Professor J van Ebbenhorst Tengbergen



Fig 1

Fig 1 Case 1 Showing pneumothorax of outer third of the right chest ten days after birth



Fig 2

Fig 2 Case 1 Film made one day later than Figure 1 Still shows air in right pleural cavity

Smith (14), in 1919, reported the occurrence of pneumothorax in an infant first examined at seven weeks of age. The labor was normal, and the child breathed after brief resuscitation. The mother noted that the child had always breathed rapidly and with difficulty. It was brought to the hospital because of eczema on the face and buttocks. The lungs showed hyper-resonance on the left side, with absence of breath sounds. The heart was displaced to the right and the breath sounds in the upper part of the right lung were poor. Roentgen examination showed cloudiness in this portion of the lung. Râles were present in both lungs.

When the child was three months of age, the condition became worse. The infant had several convulsions, and aspiration of the chest drew air. The right lung became filled with râles, bronchopneumonia developed and the child died. Pneumonia was not present before the onset of the trouble. The diagnosis was complete pneumothorax on the left side, with subcutaneous emphysema on the left side of the chest.

Flipse (15), in 1928, reported the occurrence of pneumothorax in a newborn in-

fant, delivered by forceps. When the child attempted to breathe, little air entered the lungs. It was necessary to introduce a small tracheal catheter. Respiration was established in a few moments but was of an unusual type, expansion of the chest was limited almost entirely to the left side. The catheter was withdrawn and the child cried in a feeble but normal manner. Cyanosis, however, developed on slight exertion.

Roentgen study showed the heart to be displaced almost completely to the right of the sternum. The left lung appeared about 50 per cent collapsed, with a well-defined area of pneumothorax surrounding it. By the use of oxygen during cyanosis, the child was carried along. X-ray films were made at 24-hour intervals, and showed progressive collapse of the left lung, until it was totally collapsed when the infant was two days old.

Thirty cubic centimeters of air was removed from the left side of the thorax by puncture in the midaxillary region. Immediate roentgen examination showed the heart nearly normal in position, with some expansion of the left lung.

On the following day, the lung was again



Fig 7

Fig 7 Case 5 Showing an area of pneumothorax in the outer third of the right pleural cavity (nine days old)

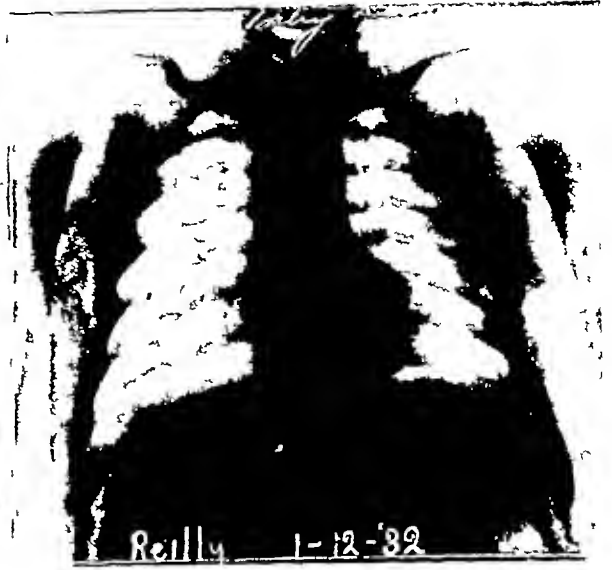


Fig 8

Fig 8 Case 6 Showing partial collapse of the right lung with an area of pneumothorax in the lateral portion of the right pleural cavity (one day old)

auscultation was normal. The roentgen examination in this case also showed on the left side an extensive pneumothorax, occupying the anterior portion of the chest. While in the former case the air was quickly absorbed, in this case likewise there was no air demonstrable within two days, and nothing else abnormal was shown.

Case 3 Female child, born Nov 28, 1935, whose birth was normal excepting that the umbilical cord was wrapped twice around the neck. The child was born asphyxiated and had inhaled meconium. The weight was 3,930 gm. The therapy was changing baths, hot and cold. Examination, made at nine o'clock in the morning, showed an absence of heart sounds excepting in the epigastrium. No cyanosis or dyspnea was present. The child had a whining instead of a normal cry. She was, therefore, sent immediately for roentgenographic examination during the earliest hours after birth. Here likewise a small pneumothorax was found but this time on the right side, and also a very broad mediastinum, indicating an enlargement of the thymus.

Other reported cases referred to by van Ebbenhorst Tengbergen are as follows:

Quispel (18) described a case of spontaneous pneumothorax in a child of eight months. A few weeks later, this child died of tuberculosis. The cause of death here was clear.

Tidestrom (19) added a case found three months after birth. The pneumothorax was not absorbed. The cause was unknown.

Weiner (20) reported a case of pneumothorax diagnosed 14 days after birth. When the child died four and one-half months after birth, pneumothorax was still present. Section showed a large communication through an open bronchus. Cause undoubtedly was a congenital malformation.

Bush (21) described a pneumothorax discovered 32 hours after birth, which disappeared after pleural puncturing. The cause was unknown.

Emmert (22) described a case of pneumothorax which was found at autopsy. The child was born asphyxiated although it had breathed superficially and irregularly. Forced respiration was instituted,



Fig 5

Fig 5 Case 3 Film made three and one half months after the film shown in Figure 4 Case 3 showing the right lung completely expanded and a marked enlargement of the thymus gland



Fig 6

Fig 6 Case 4 Showing partial collapse of the left lung with a small area of pneumothorax in the lateral portion of the left pleural cavity (one day old)

(17), within a period of three months, observed three pneumothorax cases in the newborn

Case 1 A female child who, five days after birth, on Sept 4, 1935, was brought to the Department because her color changed from red to blue and then became dyspneic. The physical investigation showed the heart sounds louder on the right than on the left, and percussion on the right side was dull. Clinically, it was thought to be dextrocardia. The roentgenogram made on September 4 showed displacement of the heart and mediastinal tissues entirely to the right. On the left side, there was a complete pneumothorax, excepting for an area of atelectasis.

The child, weighing 4,230 gm, was born spontaneously. She was not asphyxiated and had not cried abnormally. The birth was not prolonged, covering a period of approximately six hours. It was the mother's first child. The only special concern was the umbilical cord circling the neck once. Directly after birth, the child had a bluish appearance, with a white nose, and slightly cyanotic hands and feet. She did not cry normally, and the breathing was labored. The temperature was 37.2°

C, and the child sweated profusely. On the third of September, her temperature had risen to 39.6° C, with increased dyspnea. This led to the roentgenographic examination. On the fifth of September, the temperature had returned to normal, and a new roentgenographic examination was made. This showed that the air in the pleural cavity had, in great part, been absorbed. On the ninth of September, the child was again well, she showed no cyanosis, her breathing was normal, she took nourishment normally, and her temperature was normal. The third roentgenogram, on this day, showed nothing left of the pneumothorax.

Case 2 A male child, born on Oct 29, 1935, was seen, whose birth had been normal, the only condition being that the umbilical cord was wrapped around the neck once. The child was not dyspneic or cyanotic. However, instead of crying normally, he only whined somewhat painfully. Temperature was 37° C, pulse, 120, respiration, 68. The physical investigation on October 30, the day after birth, showed the heart not percussible. The heart sounds were weak and difficult to hear. The breast bone was projected forward,

born spontaneously on Jan 11, 1929. On the eighth day, the baby developed a temperature of 103° F, and on the third day, it rose to 105° F. There was a definite cyanosis noted, and a raspy cry. A clinical diagnosis of bronchopneumonia was made. The temperature continued for six days between 100° F and 105° F. On January 21, an x-ray examination of the chest was made, which showed a collapse of the right lung to about two-thirds of its normal size, with an area of pneumothorax in the outer one-third of the right pleural cavity. The heart and thymus were not enlarged, and there was no fluid noted in either pleural cavity (Fig 1, Case 1). The following day, a second film was made because of this unusual finding and to make certain that the diagnosis of spontaneous pneumothorax was correct. This film also showed the area of pneumothorax (Fig 2, Case 1). This baby was definitely cyanotic at the time of the x-ray study, but was discharged as improved on January 24. The child finally made a complete recovery, and no further x-ray studies were made.

Case 2. Peters, male, was delivered normally and spontaneously, on Nov 11, 1930. At birth, the baby was quite cyanotic in both skin and mucous membranes. A loud blowing systolic murmur was heard over the heart area, and a diagnosis of congenital heart disease probably patent foramen ovale, was made by our cardiologist. On November 19, an x-ray examination of the chest was requested. This showed no enlargement of the heart or thymus, but there was a partial collapse of the right lung with an area of pneumothorax in the outer one-third of the right pleural cavity (Fig 3, Case 2). Mother and child were discharged on November 21 and referred to the family physician. On Jan 7, 1931, at 2:30 A.M., the baby was brought into the hospital because of marked cyanosis and gasping for breath. The mother said the child had been doing well except that he became slightly blue at times. Physical examination at this time showed the baby quite cyanotic, with rapid, labored breathing. Bronchial breath sounds were heard

throughout, and a flat note to percussion over both lungs. It was impossible to hear the heart sounds clearly because of the harsh, loud breathing. A clinical diagnosis of bilateral bronchopneumonia was made, complicated by congenital heart disease and partial atelectasis of the right lung. The temperature was 105° F, pulse, 180, respirations, 76. Active treatment was continued throughout the day, and oxygen was used at frequent intervals, but the baby died that same day. No x-ray examination was made and autopsy was refused.

Case 3. Waldron, eight-pound boy, born May 8, 1931, at birth low forceps were used and labor was not difficult. The chest was x-rayed on May 20 because of slight cyanosis. This showed partial collapse of the right lung with an area of pneumothorax 1 by 4 cm in the lower outer portion of the right pleural cavity. There was no evidence of disease in the lungs or pleura, the heart and thymus were not enlarged (Fig 4, Case 3). Mother and baby were discharged in good condition on May 23. On Sept 10, 1931, at the age of four months, the baby was sent back to the x-ray department for chest examination because of cyanosis. This showed both lungs well expanded, no evidence of pneumothorax, but definite and marked enlargement of the thymus gland (Fig 5, Case 3). The thymus was treated by x-ray and a final film was made November 12, which showed the thymus reduced to normal size, and the heart and lungs normal in appearance. The cyanosis had completely disappeared.

Case 4. Curtis, female, was born on March 11, 1931, by Caesarean section because of previous difficult high forceps extraction. Mother and child left the operating room in fairly good condition. Baby was tongue-tied and regurgitated after nursing and became slightly cyanotic. Was referred to the x-ray department on March 12 for examination of the chest for possible enlarged thymus or atelectasis. The film showed partial collapse of the left lung, with an area of pneumothorax about



Fig 9



Fig 10

Fig 9 Case 7 Showing an enlarged thymus, lung fields normal in appearance (one day old)

Fig 10 Case 7 Film made after treatment of the thymus, showing reduction of the gland but there are small areas of pneumothorax in the lateral aspect of both pleural cavities X ray examination made 24 days after Figure 9 Case 7

shortly after which the child died. The section showed both lungs non-expanded. On the left side there was a pneumothorax.

Tollkuhn (23) described a case of right-sided pneumothorax in a child of normal birth. The child died after 24 hours, the cause was unknown.

Deissler (24) described a case in which the child died one-half hour after a forceps delivery. Section showed both lungs to be collapsed. Bilateral pneumothorax. Cause localized emphysematous blebs, perhaps traumatic in origin.

Gasul and Singer (25) write concerning a pneumothorax discovered three weeks after birth, with compression pneumothorax on the right side. Three days later, the child died. Sections showed rupture of a subpleural abscess. Cause infectious pneumonia.

Hotz (26) found, five days after normal birth, a right-sided pneumothorax. On the twelfth day, this was absorbed, but then a pneumothorax was shown on the left, which also disappeared several days later. Cause was unknown.

Hotz described a normal birth, five days after which there was a left-sided pneu-

mothorax, after 17 days, it had spontaneously healed. Cause was unknown.

Hotz also described a normal birth, fifteen days after which there occurred a pneumothorax with collapse of the lung, which healed spontaneously.

Willi described a pneumothorax on the left side, after a normal birth, with umbilical cord encircling, associated with displacement of the mediastinal tissues. There was no absorption of pneumothorax. The condition persisted two years afterward.

Willi also described a pneumothorax on the left side, which was first discovered after three months, showing no absorption. It was still demonstrated one year later.

Glaser and Landau (28) discovered a case of left-sided pneumothorax three weeks after birth. Five days later, the child died. Section showed a perforated abscess.

Following is a report of the seven cases observed by us during the four-year period, from 1928 to 1932.<sup>1</sup>

Case 1 Fahey, female, a first child, weighing 8 pounds and 1 ounce, who was

<sup>1</sup> During this period x ray examination of the newborn chests was routinely made.

pital from 1928 to 1932, six of these before the twelfth day, and one on the twenty-fourth day. There were four males and three females, three spontaneous deliveries, three forceps, and one Cæsarean section. Only one of the forceps cases could be considered a difficult delivery. Four of these cases were definitely cyanotic at birth. There was no mention in our cases of the cord encircling the neck, as was noted in the cases reported by van Ebbenhorst Tengbergen. Normal breathing occurred immediately in six of the cases, and it required about five minutes to establish normal breathing in only one case. It, therefore, seems unlikely that the method of delivery has anything to do with the causation of pneumothorax, but perhaps it occurs during the first inspiratory or expiratory efforts, especially when some secretion or substance enters the larynx during or immediately after birth, causing a spasm of the epiglottis under these conditions. It seems probable that rough handling, especially to the chest, in establishing normal breathing could cause a rupture through the alveoli and pleura, such as must occur in the formation of pneumothorax. The degree of collapse and the amount of air present are dependent upon the size of the rupture. No fluid (blood) was demonstrated in any of our cases, but a very small amount might have been overlooked, all of the films having been made in the supine position. More careful study and detailed observations of the newborn during and immediately after delivery are necessary to determine more definitely the manner in which pneumothorax is produced.

Practically all of the uncomplicated reported cases, including our own, recovered spontaneously in a few days, and only those cases complicated by pneumonia, abscess or congenital anomaly of the lung and pleura terminated fatally. We are convinced that many more cases of pneumothorax in the newborn would be recognized if routine chest x-ray examinations were made immediately after birth or as soon thereafter as practical.

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three-fourths inch in width, in the outer upper left pleural cavity. The thymus was not enlarged, the lungs showed no disease, and there was no evidence of fluid in either pleural cavity (Fig 6, Case 4). Mother and child were discharged in good condition on March 25.

Case 5 Walsh, male, was born on May 20, 1931. The mother was a primipara, and had a very difficult forceps delivery. The child did not breathe normally for five minutes, mother and child, however, left the delivery room in good condition. There was a large swelling (caput) on the left side of the baby's head. On May 29, the baby was sent to the x-ray department for examination of the head and chest. Films of the head showed slight depression of the left parietal bone beneath the local swelling in the scalp, but there was no definite evidence of fracture. A film of the chest showed partial collapse of the right lung with an area of pneumothorax in the outer third of the right pleural cavity, there was no evidence of fracture in the chest. Neither the heart nor thymus was enlarged (Fig 7, Case 5). Both mother and child were discharged in good condition on June 3, 1931.

Case 6 Reilly, female, born Jan 11, 1932, was a first child. Position left occipito-anterior. Under gas anesthesia, an episiotomy was done because of a rigid perineum. Simpson forceps were used. The baby breathed immediately, mother and child left the delivery room in good condition. The general appearance of the baby was good. No asphyxia, skin was pink, slight moulding of the head, and her weight was 8 pounds and 1 ounce. On January 12, she was referred to the x-ray department for possible enlargement of the thymus. The film showed none but there was an area of pneumothorax, occupying the outer third of the right pleural cavity, with partial collapse of the right lung (Fig 8, Case 6). The infant was discharged in good condition, on Jan 22, 1932.

Case 7 Kane, male, a third child, whose birth, on July 27, 1932, was spontaneous

A small amount of ether was given during the last stage of labor. Position was right occipito-anterior. There was a slight first degree laceration. Mother and child left the delivery room in good condition. The baby weighed 8 pounds, 11 ounces. The skin was pink and clear, no asphyxia, and his head showed slight moulding and small caput. Physical examination otherwise was negative. X-ray examination of the chest, made on July 28, showed a moderate enlargement of the thymus. The lungs were well expanded, and the heart was not enlarged or displaced. Films of the skull showed no evidence of fracture (Fig 9, Case 7). The baby, however, developed twitching of the arms, and a neurologic consultation was obtained July 30, on the third day. This revealed rhythmical contractions of both upper limbs, chest and neck, and at times also of the lower limbs. The contractions were more marked on the right than on the left side. The twitches improved after the withdrawal of 3 c.c. of bloody spinal fluid. A diagnosis of intracranial hemorrhage was made. Four doses of x-ray were given at weekly intervals for the enlarged thymus. An x-ray examination of the chest was again made on August 20, which showed the thymus reduced to normal size, but there was a partial collapse of both lungs, with a small area of pneumothorax in the outer upper portion of both pleural cavities. The heart was not displaced and there was no evidence of fluid in either pleural cavity (Fig 10, Case 7). In March, 1933, following bronchopneumonia, a film of the chest showed a mottled opacity involving the middle third of the right lung area, suggesting residual pneumonia rather than fluid. The left lung was well expanded and clear. This baby was treated in the neurological clinic for convulsions until April, 1933, when he was transferred to another hospital.

#### SUMMARY

Seven cases of pneumothorax in the newborn were encountered by us in the x-ray department of the Misericordia Hos-

Recent papers have confirmed this finding and have further pointed out the presence of low-grade changes of a similar nature in the contralateral joint in cases in which clinically the deformity was only unilaterally manifest. Only occasionally are there changes of the joint surfaces of the proximal carpals or of the intercarpal joint spaces. Roentgenologically, the alteration of the plane of the joint surface of the radius produces a console-like appearance of the facet of the radius, although the outline of the articular surface appears scalloped. By such transformation a rather triangular arrangement of the carpal bones may result. One of us has observed a similar static deviation whereby the arrangement of the wrist bones presented the above-described triangle in a lesser degree and without clinical symptoms in several cases as an incidental finding. Such findings may easily be confirmed when the attention of the roentgenologist is called to static relations of the radio-ulnar-carpal articulation. We, therefore, feel that, besides clinically manifest Madelung's deformity, there occur instances of incomplete and latent deformities.

Madelung's deformity is, in its classic form, unmistakable and presents the appearance of a subluxation of the wrist with the dorsally prominent ulna and the radius bent or curved forward and toward the ulna. On inspection, the ulnar prominence is seen to be accentuated, there is a "silver-fork" deformity, and extension and circumduction are limited at the wrist. In the posterior form, flexion is limited. Generally there is a moderate limitation of abduction, and there may or may not be limitation of pronation. Pahl and Fick state that limitation of the normal function is only a matter of degree. As Campbell points out, the dorsally prominent ulna may be pressed down to a level with the radius, but, immediately on releasing the pressure, it returns to its former position. This is probably due to laxity of the distal radio-ulnar ligaments. There seems to be little loss of function following the cessation of the active process, however, in cer-

tain instances the wrist is weakened and the disability progresses. Schnek and Bsteh report cases associated with fractures of the radius and of the os naviculare, and also with perilunar dislocation of the carpus, which might be consistent with decreased ability to resist trauma.

As early as 1825, Bégin noted forward dislocation of the wrist of laborers using heavy press levers. These men reported little or no discomfort, and Bégin attributed the deformity to occupational stretching of the ligaments. In 1839, Dupuytren mentioned a similar deformity and in the following year Lasanagie described a "luxation consécutive de l'articulation radio-carpienne." The first positive report, however, of the condition as we know it, was that of Malgaigne, in 1855. Other cases, probably falling into the same category, have been mentioned by Busch (1864) and Jean (1865).

In 1878, before the Seventh German Surgical Congress, Madelung described the dissection of a unilateral wrist deformity which he had encountered at an autopsy of a 20-year-old female, and mentioned 12 other similar cases which he had seen. The main features, as described by him, were lateral and dorsal bowing of the lower end of the radius, with volar inclination of the distal radial articular surface and apparent forward subluxation of the carpus. He found that the dorsal edge of the distal end of the ulna was prominent and well preserved, while the palmar edge was atrophic.

Since Madelung's report the deformity has been associated with his name, and has received considerable attention in the German, French, and Italian literature. In French, the deformity is known as the Madelung-Dupuytren or Madelung-Dupuy's subluxation. In 1908, Siegrist collected 62 cases, only 10 of which were males. It was not until 1908 that the first paper dealing with the deformity appeared in an English journal (Brinsmade). The following year Stetten, in reporting a rare form of this condition, thoroughly reviewed the subject in a comprehensive article which

# MADELUNG'S DEFORMITY OF THE WRIST

WITH REPORT OF A CASE

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**M**ADELUNG'S deformity of the wrist is a rare condition, usually bilateral, developing at the distal end of the forearm of young individuals between the ages of 8 and 20 years—80 per cent of such deformities appear between the ages of 11 and 15 years. The deformity is essentially an anterolateral curvature of the distal third of the radius, with dorsal prominence of the joint end of the ulna. Contrary to early descriptions, it is not associated with an irreducible dislocation of the wrist. The lesion progresses slowly and by the end of one or two years the deformity is complete. During the active developmental stage, pains may or may not be present. If there is discomfort from pain or ache, it may be aggravated by forced movement, chiefly by extension.

The anatomical changes are best seen in roentgenograms which include the hand and the entire forearm. There is bowing of the lower third of the radius, usually dorsal and lateral. The articular surface is tilted medially toward the volar side and slightly rotated inward and backward, and the carpus is thrown forward. The increase of the axial curve of the radius, especially along its medial aspect, results in marked bowing with shortening of the length of the bone. The ulna is not primarily affected, but, due to the shortening of the radius, the distal joint end of the ulna is made to override the carpus and it becomes unduly prominent, as is demonstrated in lateral views. In 96 per cent of the cases this overriding takes place dorsally and the carpus is displaced anteriorly. Rarely, as in Stetten's case, the reverse occurs. The relative overgrowth of the ulna is of the greatest importance and very often gives rise to the first clinical manifestation of the deformity.

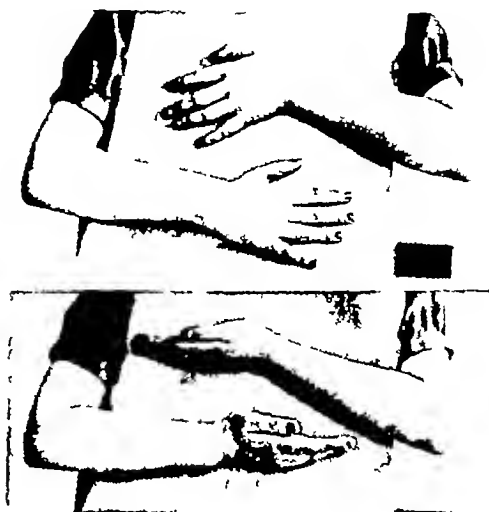


Fig 1

Especially characteristic is the widening of the interosseous space due to the exaggeration of the normal flexor concavity of the distal end of the radius. The arrangement of the carpal bones presents more or less alteration, chiefly as regards the static relationship between the distal end of the forearm and the proximal carpal series, while the individual bones mostly remain normal in shape and outline. Schneek and Melchior have drawn attention to more or less marked changes in the declination angle of the joint surface of the radius with a corresponding pyramidal arrangement of the proximal carpal bones (Figs 1 and 2). Köhler points out that instead of the normal slightly curved arrangement of the carpals, paralleling the joint fork of the forearm, there is a V-shaped arrangement with the os lunatum forming the vertex of the triangle. This is mainly observed in cases of bilateral true Madelung's deformity.



Fig 4



Fig 5

joint have produced such a secondary deformity

#### CASE REPORT

L. R., No 62,957, a 16-year old native-born Russian Jewish school girl, was admitted to the Surgical Service of Dr George Heuer, New York Hospital, April 27, 1934, for thyroidectomy. In addition to her history of goiter, she stated that at about the age of nine years she began to have "growing pains" in both wrists, which were especially noticeable on motion. These pains gradually subsided after a period of about two years, and her parents noticed a deformity in both wrists which was most marked on the right side. There has been no change for the past four years, the joints are no longer painful, and there have been no other symptoms referable to the wrists.

Examination of both forearms shows bilateral deformities of the wrist (Fig 1), more marked on the right side. The ulnar prominence is exaggerated on both sides, and the carpus appears dislocated anteriorly. Just above the wrist there is a slight volar concavity of the radius, which appears bowed dorsally and laterally. The styloid process of the ulna is unusually prominent and appears dislocated posteriorly. Both extension and abduction are limited. There is no tenderness.

X-ray examination of the right wrist reveals the carpus to be projected anteriorly but not actually dislocated (Figs 2 and 3). The distal end of the ulna projects dor-

sally, overriding the carpus, but the form and structure of this bone show no variation from the normal. The distal articular surface of the radius is inclined in a medial and volar direction, and is scalloped in outline. There is a small hyperostosis at the medial edge of the radial articular surface. The inner border of this bone appears shortened, and the proximal outline of the carpus presents a pyramidal contour in the anteroposterior view (Fig 6-A) instead of the normal curved arrangement (Fig 6-B). The individual bones show no changes in contour or structure. There is some condensation about the dorsal edge of the radial articular surface.

Roentgenograms of the left wrist show a similar appearance of the carpus and of the articular surface of the ulna, but in a lesser degree (Figs 4 and 5).

#### DISCUSSION

The reported case represents the final appearance of a true bilateral Madelung's deformity. Clinical and roentgenologic findings suggest that we are dealing with a primary lesion about the epiphyseal zone of the distal end of the radius, which later, due to disturbance of the normal growth process of the articular end of the bone, has produced, secondarily, a deformity of all the adjacent skeletal parts. While the anatomical deviation, although not a true dislocation in these cases, reminds one of the basic features of habitual dislocation of the shoulder and of the patella, the anatomical lesions at the wrist joint present an



Fig 2



Fig 3

included a very complete bibliography. He summarized the reports of 62 cases of the usual anterior deformity and two (including his own) of the rare posterior type. The following year Stokes added two more, and, in reviewing the literature since that time, we are able to bring the number of reported cases of Madelung's deformity to about one hundred. Though probably not so rare in this country as the literature would indicate, it is nevertheless very uncommon, in the material of the New York Hospital but one case was noted in 25,000 examinations. It can be assumed that with the increasing number of examinations which are resulting from the Workmen's Compensation Act, and with the wider use of roentgen examinations in traumatic surgery, there will be more observations and reports of the condition.

Of 73 cases in which the clinical data were reported, 86 per cent occurred in females. The age of onset varied from 8 to 23 years, but in a large majority it was between the ages of 11 and 15 years, i.e., at the time of puberty. As to the actual cause of the deformity, there has been much diversity of opinions. Occupational stretching with resulting relaxation of the ligaments, strain on the wrist during the growth period, muscle contractures, infantile and adolescent rickets, heredity, congenital syphilis with osteochondritic lesions, osteitis fibrosa, and endogenous disturbance of the bony-cartilaginous development have all been suggested. The conception that the deformity is a result of en-

dogenous disturbance is strengthened by the frequency of bilateral deformity, either complete or silent, by the localization of the primary lesion in the epiphyseal zone of the radius, by the often observed associated underdevelopment of the entire forearm, and by the poor results following an operative elimination of the function of the flexor muscles. Some authors regard this condition as a congenital deformity and suggest that first attention to it is directed only at an age when strain on the part and constitutional changes due to malnutrition exert their influence.

Cases have been reported in which there have been associated other anomalies: homolateral cervical rib (Kayon), sacralization of the fifth lumbar vertebra (Ingber), multiple osteogenic exostoses (Gadrat), and congenital dislocation of the hip. Donovan and Racanski have reported cases simulating a Madelung's deformity following bone injuries in early childhood. These cases should be considered as secondary static deviations following disturbance of the normal fracture healing, and they do not represent the true Madelung's deformity. And so Fick, Zeitlin, Bertolletti, Czerny, and Delbet distinguish between a true and false Madelung's deformity. Springer suggests the term "secondary fork-hand" and reports cases as "*manus furca post fracturam, post subluxationem, e distorsione*". There have been reports that polyarthritis, rheumatoid infections, osteomyelitis, bland inflammatory conditions, and toxic involvement of the

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appearance similar to that seen in the end-stages of other well-known growth disturbances, such as Perthes-Legg-Calvé's,

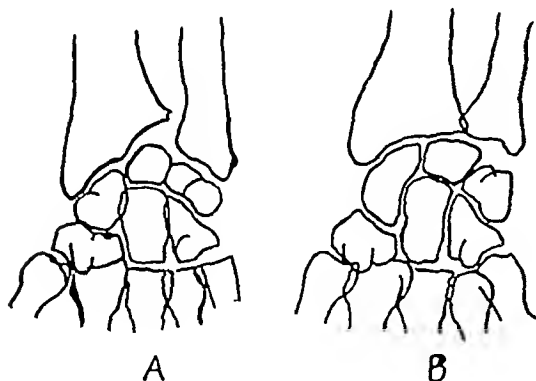


Fig 6

Köhler's, Osgood-Schlatter's, and Scheuermann's diseases. It is the opinion of the authors that, besides local disturbances of enchondral ossification, *i e*, replacement of cartilaginous by osteoid tissue, whatever this may be due to, likewise in cases of Madelung's deformity, a dysplastic malacia develops and probably produces histologic lesions at the epiphyseal zone similar to that seen in "local necrosis." Because of this there is inability to withstand mechanical strain, which eventually leads to a rearrangement of the anatomical relationship between the primarily involved radius and the adjacent ulna and carpal bones. It is altogether possible that in Madelung's deformity and in the previously mentioned diseases endocrine and constitutional disturbances may play a part in producing these conditions. It is of interest to note that our patient and one of those reported by Stokes were both suffering from hyperthyroidism. There are recent reports which deal with the possible relationship between endocrine disturbances and Madelung's deformity. While the results of careful endocrine and metabolic studies are not striking, there have been in a few cases variations from the normal. One of us had the opportunity of observing three cases, and in view of this experience we are inclined to agree with Stieda, Gickler, Red-

ard, and Stetten that the deformity develops secondary to a lesion of the cartilage of the distal radial epiphysis, with subsequent disturbance of growth at this point. We feel that in the cases of true Madelung's deformity, a mechanical cause consisting in a single injury or frequent repeated minor accidents constitute the primary cause of the initial lesion. The abnormal reaction of the bone to trauma is possibly due to endocrine and constitutional disturbances affecting the bony-cartilaginous growth. This seems to us a satisfactory explanation for the development of a deformity of the radius in the presence of a normal ulna and normal carpal bones.

#### SUMMARY

- (1) A case of Madelung's deformity of the wrist is reported
- (2) The clinical and roentgenologic findings are noted
- (3) The etiologic and predisposing factors are discussed

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upon by a court of last resort, but it may be answered by analysis. The patient goes to a physician primarily for the diagnosis of a condition or for such treatment as may be indicated. The physician makes an examination, part of which consists of making a roentgenogram. If the roentgenogram is made by the physician himself, then the plate or film is a part of the record of that particular case. It is just as much a part of his examination as any instrument used, device or method employed. It would be unreasonable to contend that a patient owns a history sheet. It, nevertheless, is a part of the record of an examination, although it may contain the doctor's conclusion as to the result of the examination. The history sheet records the temperature, pulse rate and numerous other items, while the roentgenogram records some other items which refer to the findings, and which are just as much a part of the records of important items necessary for the correct diagnosis of the patient's condition as are the temperature, color of his skin, or whether his urine contains albumin or casts.

"The patient pays for the physician's opinion, or, in other words, his examination and the possible treatment, not for the means by which these are determined. The patient does not pay for the x-ray plate any more than he does for the thermometer, stethoscope, or microscope which were used to determine his temperature, heart sounds, or the condition of his urine.

"In the absence of a specific agreement, the roentgenogram belongs to the person who made it. This conclusion is borne out by analysis. Courts have consistently held that a prescription written by a physician does not belong to the patient for whom it was written. He does not pay for the prescription but for an opinion of his disorder and for treatment for the same. The prescription is nothing more than an order to the druggist to supply the patient with the medicine mentioned. The druggist fills the order and files it as his voucher or authority for supplying the drugs mentioned in the order. The situation is similar to that

of writing a check on a bank. The check, of course, is not money. It is simply an order on the bank, as custodian of the depositor's money, to pay a certain amount of money to the holder of the check. Unless some specific agreement to the contrary is made, the roentgenogram belongs to the individual who made it.

"An additional analogy is found in the question of the ownership of photographic negatives. A person goes to a photographic studio for a photograph, but he does not pay for the plate any more than he pays for the camera. The courts have repeatedly decided that the plates or negatives belong to the photographer, who is, however, required to put their use to proper purposes. The following court decisions depend upon the foregoing point: *American Mutoscope Co. vs Edison*, 137 Fed R, 262, *Itzrovitch vs Whittaker*, 39 So R, 499, *Schulman vs Whittaker*, 39 So R, 707, *Burrows et al vs Sarony*, 111 U S R, 53, *Thornton vs Schreiber*, 124 U S R, 612, *Hottinger vs Jackson*, 11 Queen's Bench Decisions, 627.

"As you probably know, I have been pretty active on this particular subject for a long time. I read a paper upon it before a joint meeting of the Western Roentgen Society (the progenitor of the Radiological Society) in 1918, which was published in the 'Journal of Roentgenology' that year, and I introduced and had passed the resolutions mentioned in the early portion of this letter. Last March I presented a more exhaustive paper on the same subject, before the Milwaukee County (Wis) Roentgen Society, which will be published in the 'Radiological Review'<sup>3</sup> soon.

"I do not know just how your Indiana law reads, but in Illinois, when I have refused to turn over roentgenograms, when lawsuits have come up for trial, I have been served with a *subpoena duces tecum*, which orders me to bring all records, documents, and roentgenograms pertaining to the case, and I do not doubt but that your laws are about the same. As a matter of fact, there

<sup>3</sup> Radiological Review, May-June, 1925



# SOME LAWSUITS I HAVE MET AND SOME OF THE LESSONS TO BE LEARNED FROM THEM<sup>1</sup>

(Eleventh Installment)

By I S TROSTLER, M D, F A C R, F A C P, Chicago

## OWNERSHIP OF ROENTGENOGRAMS

WHILE the question of the ownership of roentgenograms appears to be fairly well settled and established by the two Michigan District Court decisions<sup>2</sup> and the recent Michigan Supreme Court decision which will be mentioned later, it may be found useful and instructive for us to handle similar situations. We will recite some of the particulars of a suit.

Twelve years ago, a radiologist in a neighboring city wrote me "I am being sued for possession of films taken of a patient.

"This suit is preliminary to a suit for malpractice, to be filed against the patient's attending physician, and the patient's attorney is evidently desirous of obtaining possession of the films for reasons best known to themselves.

"They make the same old stipulation that these films are wrongfully in my possession, as his [the patient's attorney's] client has paid for them and that they are therefore his property.

"I shall appreciate it if you can inform me of previous decisions rendered in test cases."

I replied "Replying to your query of yesterday, will say that I have at this time no knowledge as to any definite decision from a court of record regarding the ownership of roentgenograms as such, but I have defended the position that roentgenograms are records of examinations and that as such records, they are the property of the radiologist who made them, or of the insti-

tution where they were made. Some three or four years ago, I introduced resolutions, which were passed by the Radiological Society of North America, that 'It is the sense and judgment of this Society that all roentgenograms, plates, films, negatives, photographs, tracings or other records of examinations are hereby declared to be the exclusive property of the radiologist who made them or of the laboratory where they were made.'

"Now then, the law is very strict that physicians must follow established modes of practice. Naturally this may be inferred to mean more than the treatment of disease, and if they depart from recognized methods of practice, they do so at their peril. Why cannot we carry this just a little bit farther and say that the accepted mode of practice is for roentgenologists to retain possession of the roentgenograms, which are a part of their records, and in failing to do so, they depart from established rules and methods and consequently make themselves liable?"

"Again, it has been held by courts all over this country that the liability of physicians depends largely upon whether their practice in the case in question has been in agreement with the particular school of medicine which they practise. While radiology is of no special school, the methods followed by radiologists should be adjudged as regular if they follow the established methods of their specialty.

"I recently had a careful search made for decisions applying to this subject, by a very competent attorney. Under date of Feb 14, 1924, he wrote to me that he and his associates had been unable to find any decision referring directly to this subject. He gave me the following, as an opinion: 'As to the ownership of an x-ray plate, this question has never been squarely passed

<sup>1</sup> The Editor desires to state that much of the matter herein has to be printed in form as received without normal punctuation or phrasing.

<sup>2</sup> Two decisions from the Circuit Court of Ingham County, Mich., and Genesee County, Mich., respectively. Published in RADIOLOGY for December, 1932.

recommends exactly what we have many years ago declared to be unethical. I refer to the giving of prints, copies, or films to patients.

After more or less rambling argument pro and con the same writer states "There are far too many roentgenologists and the poorer two-thirds ought to be prevented from claiming either the remuneration or the authority of the skilled ones, and this applies particularly to roentgen therapy." Perhaps the American Board of Radiology may help solve that portion of Dr. Brown's problem.

He concludes by saying "It would seem, therefore, that it is the duty of some one in authority to have the courts settle all the problems connected with x-ray films of pathologic conditions for the benefit of the patient and the protection of the doctor." Evidently he has never heard of the Radiological Society, nor is he aware that that body fixed the status of the ownership of roentgenograms as long ago as Dec. 16, 1920, and that the recent court decisions in Michigan are the direct outcome of the Radiological Society's action. The writer knows this, because he wrote the Resolutions which were adopted at that meeting and has sent out approximately 160 reprints and letters regarding that particular subject to radiologists, attorneys, insurance companies, hospitals, industrial commissions, and the like. He has personally pleaded with attorneys and begged them to start legal actions to try to force him to yield possession of roentgenograms, but none would proceed, *because he knew that he could not win*.

Therefore, we still maintain that the roentgenograms belong to the radiologist or to the establishment where they are made, as a part of the record of examinations of patients, unless a specific contract to do otherwise than examine has been entered into. The courts are just beginning to recognize and acknowledge what we have known for a long time, and now comes a man, who from his own statement, "does not know what it is all about," and wants to have "some one in authority" de-

cide for him. We—the Radiological Society—have decided, and are well satisfied with our decision after over fifteen years have passed since the passage of the Resolutions promulgating our decision (see page 84, 1935 Membership Roll of the Radiological Society of North America).

#### HEMIPLEGIA AND HEMIOPHOSIA

While by far the greater number of medical malpractice cases with which the writer has been connected and concerning which he has advised regarding the defense, were based on injuries resulting from the use of the roentgen rays, there has been a considerable number due to other causes. Among the latter group was one that was the source of a great deal of pleasure and gratification to me.

An attorney for a large insurance company called me over the telephone in 1929 and asked me, if, in my opinion, a facial, lingual, and internal ocular paralysis could be caused by an osteopathic treatment. I replied that I preferred to have more time to consider the question and possibly to consult neurologists and ophthalmologists before I expressed a definite opinion. I asked him to write me the full particulars and, upon receipt of same, I would give him the best that I knew or could find out. His letter read "As *per* our telephone conversation in this case, the following is a résumé of the facts:

"The patient, H. S., an electrical engineer of 50, called at the office of our assured, complaining of neuritis in the shoulders and a general nervousness. The osteopath placed the patient on a table, lying on his side. While working on the patient's neck and head the patient developed a partial paralysis affecting his right side and also his right eye and tongue. Patient's mind was affected and he was only semi-conscious. The total incapacity lasted for about nine weeks. At the present time he is partially able to resume his duties.

"He is still suffering from lack of co-ordination and numbness in his whole right side. The doctors who have examined him

are numerous decisions from supreme courts, notably from Oklahoma, Iowa, Vermont, Texas, Virginia, and North Carolina, that roentgenograms may not be admitted in evidence unless they have been identified by the person who made them, and in three of these States (North Carolina, Virginia, and Oklahoma), the decisions state that the plates or films must have been constantly in the possession of the person who made them in order that they be admissible as evidence. In view of these facts, might it not be well, of course, with the knowledge and advice of the attorneys for your associate and yourself, that you freely surrender possession of the plates in question, with the idea of taking advantage of the points made in the decisions just quoted (or rather cited)?

"As far as I know, the bringing of this suit is probably the first of its kind, and I assure you that I am extremely interested in it. While I feel sorry for you and for your friend, I am frank to say that I am glad that this question is about to be tested and decided before a court of justice. If I can be of any use to you or to your friend, be assured that it will be a pleasure for me to aid in maintaining the position and opinion that I have held for over twenty years.

"Another important element which may have a weighty bearing in your case is the question as to how you rendered your bill for the services in which the roentgenograms were a part. Did you bill the patient for radiographic or roentgenographic examinations? If you did that, it will of itself maintain your position and contention, but if you billed the patient for roentgenograms or x-ray plates, it is up to you to deliver them. This is in conformity with an opinion of one of the best medico-legal lawyers in the United States. In his communication to me, regarding this subject, he wrote 'If the proprietor of the roentgen laboratory is employed to make a diagnosis and his bill is rendered for diagnostic services, the plate or film presumably remains his own. If he has not been employed to make a diagnosis, but to make a plate, then

the plate belongs to the person ordering it (*the referring physician*)'."

Several months later, my Indiana friend wrote "I took your letter to the patient's attorney, who is also a personal friend of mine. He told me that the patient was shown your letter and that on his advice they [the patient] had best withdraw the replevin suit against me. This was done and I have heard nothing further since that time."

The foregoing is a recital of like proceedings known to the writer to have occurred not less than a dozen times since 1918, and until the epoch-making decisions from Michigan, previously mentioned, we have been unable to induce attorneys to push suits for possession of roentgenograms when we have been able to present our arguments. To cap the climax and make Michigan the pacemaker, in a suit for possession of roentgenograms which was carried to the Supreme Court of Michigan (*McGarry vs J A Mercer Co*), this highest court in that State last June (1935) decided in favor of the physician plaintiff and appellee that the roentgenograms in question belong to him. The decision has not been published at this writing.

Here is a victory upon which your writer feels he has had considerable influence. He acknowledges much aid in the work from Dr. Sam W. Donaldson, of Ann Arbor.

Dr. Philip King Brown, Supervisor of Medical Service in the Southern Pacific Hospital, at San Francisco, in a letter in the "Journal of the American Medical Association" of Feb. 1, 1936, discussed "The Ownership of X-ray Films." Among other things, he said "If it were necessary to decide the question at once and finally, I should say that *since the profit in roentgenology is so great* [italics mine], it seems to me that the taker of the original film could supply a 4 by 6 photograph of the film or of such films as established the diagnosis, for passing on to the patient." In other words, this distinguished physician would have us become medical photographers, exactly what we have for nearly forty years been fighting to keep away from. And he

due directly to the manipulations of the defendant, may it not be argued that the plaintiff, having high blood pressure, was more liable to have a cerebral hemorrhage, and that the severity of the manipulation was the drop in the bucket that caused it to overflow? I believe that is possible, and if the hemorrhage occurred soon after the defendant's manipulation, it is probable. So, while the alleged injury could not be a direct cause of the ailments that plaintiff claims, it might have been an exciting cause, because it precipitated a condition which was imminent, and would as likely have occurred if the plaintiff had stubbed his toe while walking, or incurred some similar slight harmless or otherwise innocuous accident.

"Similar events such as this occur frequently in the practice of medicine and surgery, and the patients have no recourse from the effect of proper treatment, provided the person administering the treatment is a properly licensed practitioner, exercising due care in the administration of the treatment. Physicians do not and are not expected to guarantee good results or good effects following their treatment. Physicians are not insurers of cures or even of benefit from their treatment.

"The foregoing embodies my opinion, and outlines something of a line of defense which can be proven by expert testimony, and which, it seems to me, should enable you to secure a verdict for the defendant."

The attorney for the insurance company replied as follows: "We are in receipt of your letter, giving us your report in the above captioned matter, for which we thank you. The report is very full and is very helpful and we want you to know that we appreciate it very much."

The case was settled for \$1,500 out of court.

#### PRACTISING MEDICINE WITHOUT A LICENSE

Several years ago I was asked to help an Eastern group in the prosecution of several men who were practising medicine without the necessary state license. I wrote "Of course you know that you must catch your

rabbit before you cook it. Likewise, you have to have a patient or—better—several patients, who have been treated by your culprits, and who have paid for the treatments. And it is to be preferred that these patients can show and prove that they did not have the ailments or disease that the irregular practitioners treated them for. Although this latter requirement is not absolutely essential, it is liable to help toward a conviction, because it shows the ignorance of the irregular practitioners. Of course, their ignorance has nothing whatever to do with their guilt of practising medicine without a license, but juries are peculiar 'critters,' and usually, some such thing as proof that the culprits took the money from the sufferers without giving them anything for it is considerably more liable to induce a conviction than without that kind of evidence, if you can get that sort of evidence into the record of the case.

"In furtherance of the proposition of prosecution of non-medical practitioners, your attention is called to a decision from the New Jersey Supreme Court, which seems to me might be of considerable value in at least one of the cases you mention.

"Chiropractors cannot legally use electricity in the treatment of patients according to the decision of the State Board of Medical Examiners *vs* Harry De Baum. It seems that De Baum had been charged with practising medicine without a license, having treated a patient with some form of electricity and had been paid a fee for the treatment. The case was tried before a judge and without a jury, and the defendant was acquitted of the charges, in the First Judicial District Court. The State Board appealed the case to the State Supreme Court, which reversed the finding of the lower court (in Bergen County). The Supreme Court said "Electricity is a dangerous instrumentality unless restrained within proper limitations, and its use as applied to the human body should be under the direction of authorized persons. Its use in the case for which the defendant was prosecuted was a part of the art of healing, and in no wise involved the function of

say that he has a permanent loss of the use of the outer quadrant of the right eye

"The patient alleges that the injury was caused by turning his head too far to the side

"We are anxious to know if such condition could result from an osteopathic treatment or whether this condition indicates some chronic condition that simply evidenced itself at the time of this treatment

"The osteopath advises us that after the partial paralysis developed he took the patient's blood pressure, which he found to be 162 systolic

"We will be pleased to have your opinion herein "

Three days later I wrote "In reply to yours of June 21st *re* above-captioned case, will say that after carefully considering conditions, eliciting the opinions of two high-class neurologists and a high-class opthalmologist, correlating their opinions with what I know from my own experience and knowledge, I am firmly convinced that the hemiplegia and hemianopsia complained of by the plaintiff in the case in question, are *not* directly due to the alleged cervical spinal injury—the result of turning his head too far to the side "

"Neck injuries, such as are alleged, might and frequently do produce paralysis of one or both sides of the body *below the location or point of the injury, but they never affect the eyes, and from our knowledge of human anatomy and physiology, we know that they cannot affect the eyes*

"It is comprehensible how the tongue might be affected, if the injury resulted in a closure (partial) of the jugular foramen in the base of the skull, whence the tenth, eleventh, and twelfth cranial nerves make their exit from the cranium, but if the tongue—which is innervated by the twelfth nerve—became paralyzed wholly or in part, due to an injury at this point or distal to it, there would *almost certainly and positively* be injury and paralysis of the functions of the tenth and eleventh nerves. The tenth nerve is the vagus or pneumogastric nerve, and has one of the widest distributions of any of the nerves in the inside of the body,

while the eleventh nerve is the spinal accessory nerve and is an important nerve affecting motion. Also, none of these nerves has anything whatever to do with the eyes, and furthermore, *no nerve outside of the cranium has anything to do with the eyes nor with sight or vision*

"Hemianopsia—which is the technical term for loss of vision in one-half of the eye or normal visual field—is usually caused by a lesion between the optic chiasm and the occipital cortex, a lesion in the cortical center controlling vision, or in the angular gyrus. All these are parts of the brain, and *are located within the cranium*, far removed from the neck, and could not by even the greatest stretch of imagination be affected by an injury to the neck, in a direct manner

"The fact that the paralysis involved the right eye and the right side of the body points definitely and conclusively toward either an apoplexy or a thrombosis, *within the cranium and in the brain*, in the centers which control the right side. If the paralysis came on slowly, the cause would most likely have been a hemorrhage, due to the bursting of a blood vessel in the brain and pressure from the blood, in the region controlling these parts. If the paralysis came on suddenly, that would in all likelihood be due to the lodging of a blood clot or of some similar substance or tissue, at or near the same location

"The blood pressure at 162 in a man of 50 is high enough to rather strongly suggest, if not to absolutely justify, a diagnosis of cerebral hemorrhage in this case

"Incidentally, and entirely aside from the considerations herein discussed, a blood pressure of 162 should have been enough for the defendant to have been warned against applying his vigorous neck-twisting therapy. But being an osteopath, he had had no training in the significance of that, and *that is one more good reason why your company should not insure osteopaths* <sup>4</sup>

"Now then, while we are satisfied that the alleged ailments are not and *can not* be

<sup>4</sup> Incidentally, this insurance company quit insuring osteopaths the next year after this letter was written.

State Bd of Med Exam *vs* Fife *et al*, a Louisiana case (111 So R, 58)

William *vs* Scudder, an Ohio case (931 N E R, 481)

People *vs* Banks, a Michigan case (209 N W R, 935)

"An electrotherapist case, Larson *vs* State (Texas) (285 S W R, 317)

"I sincerely trust that you will find ample in the foregoing to show what you need to make those fellows behave I would like to hear how you come out"

I never learned the result of the attempts to make these men quit practising medicine without being licensed

#### "MYRIADS OF PAPILLOMAS" AN UNUSUAL RESULT

The following letter to me, from a radiologist in a large Southern city, my reply, and his reply to me, all within the last week in 1924, tell an interesting and instructive story

Dr E's letter read "I have been very much impressed by the articles you have written relative to expert testimony in cases pertaining to x-ray burns At the present time I am going through the throes of such a distasteful experience, the case having come up once and resulting in a mistrial

"To begin with, I want to give you the following history In the Summer of 1920 a man came to my office with myriads of papillomas on each side of his face, and extending down into the bearded portion of his neck, and consulted me for treatment He had had these warts removed a number of times by the electric needle, and they immediately returned, so I advised the only course that I knew—x-ray treatments I gave him the following dose to each side 8 in distance, 1 mm aluminium, 5 ma, 9 in S G, for 5 minutes

"The patient had to leave the city that night, and before he went I told him that I thought he might have some swelling in the parotid region as well as soreness in the glandular structure of the neck Two days later he returned to my office, and com-

plained of excessive dryness in his mouth and throat, which I naturally expected would follow the normal routine

"Upon examination in the office of a laryngologist, he was found to have his mucosa, from the uvula downward, as white as cotton, and the laryngologist really thought it was a case of diphtheria Of course I became very much alarmed, although I knew of nothing to do to stay the progress

"Following this, a very marked edema of the glottis appeared and I for a time feared that we would have to do a tracheotomy, but this subsided to a sufficient degree to eliminate the necessity of such a step

"Two or three days later the glands of the neck began to swell, and gradually reached the extent where the whole structural outline of his neck was in line from almost the tip of his chin to the angle of the jaw on each side, to the nape of his neck I did not know what to do, of course expecting a horrible dermatitis to begin in the usual time, from ten days to two weeks after the treatment

"At the expiration of three weeks there was nothing more than a blush on the skin, which gradually became deeper and more angry, and by the end of the fourth week I saw staring me in the face a definite x-ray burn The glands of the neck remained in that condition for at least six months before any suggestion of retraction in the fibrous tissue accumulation manifested itself, and you can imagine what a horrible advertisement this was for me, being constantly on the street, and possessed of a vociferous personality

"The dermatitis on the skin gradually subsided, after progressively reaching and going through the stage of ulceration, and I thought the matter was all over so far as danger was concerned

"The patient in the meantime consulted Dr B, at Johns Hopkins, Dr J, at Philadelphia, and Dr S, at New Orleans He then came to my office and told me after the conference with the stated authorities that he realized he was the goat and could hardly attribute the unfortunate experi-

hand manipulation which, let it be said, is supposed to be the chiropractor's method of treatment" The Court further said "This Court is unable to conceive of any hypothesis in this case on which the use of electricity in the manner stated is a part of the practice of chiropractic The action of the defendant as stated is considered by this Court to be contrary to the prohibitory provisions of Section 10 of the act licensing physicians to practise medicine, enacted in 1921

"The following are excerpts from some of the authorities, regarding what constitutes the practice of medicine

"A physician is one lawfully engaged in the practice of medicine and includes all who practise physic or surgery and is not limited to any one school of practitioners' (30 Cyc, 1544)

"A surgeon may be said to be a physician who treats injuries, deformities, disorders It would also include treatment of disfigurements or other physical conditions by manual operations and the use of surgical instruments and appliances' (30 Cyc, 1546)

"Liability under a statute prohibiting the practice of medicine without a license is not affected by the fact that the operations were performed and the medicines were administered under the direction and charge of a licensed physician and surgeon' (30 Cyc, 1564)

"The New York State statute regulating medical practice defines the practice of medicine as follows 'A person practises medicine within the meaning of this article except as hereinafter stated, who holds himself out as being able to diagnose, treat, operate or prescribe for any human disease, pain, injury, deformity or physical condition, and who shall either offer or undertake by any means or methods to diagnose, treat, operate or prescribe for any human disease, pain, injury, deformity or physical condition

"The New York statute regulating medical practice applies to 'every means and method that could be used or claimed to be used to relieve or cure dis-

ease and deformity, unless excepted by the statute' (217 N Y Supp, 98)

"Superfluous hair on the face is a deformity within the meaning of the New York State Public Health Law, and one who, not being a licensed and registered physician, holds himself out as being able to successfully treat such deformity and undertakes to treat it with an electric needle violates the statute regulating the practice of medicine, and under the statute is guilty of a misdemeanor and cannot recover for services rendered in giving such treatments' (102 N Y Misc R, 97)

"The first three of the foregoing excerpts are recognized all over the United States, and should prove useful in the prosecution of your culprits In addition to the foregoing I call your attention to the following citations, which you may have looked up if you feel as though you need them

"The practice of medicine is defined in the following

*Loucks vs Ionia Circuit Judge*, a Michigan case (151 N W R, 623)

*State vs Yee Foo Lum*, a Utah case (147 Pac R, 488)

*Commonwealth vs De Lon*, a Massachusetts case (106 N E R, 846)

*Milling vs State*, a Texas case (150 S W R, 434)

*Frank et al vs South et al*, a Kentucky case (194 S W R, 375)

*Board of Examiners vs Fregner*, another Utah case (154 Pac R, 941)

*Swarts vs Sveeny*, a Rhode Island case (85 Atl R, 33)

*Commonwealth vs Seibert*, a Pennsylvania case (105 Atl R, 507)

*State Bd of Exam vs Brown*, a Colorado case (198 Pac R, 274)

A North Carolina case, N C Supr Ct R, 1915, 33 Guilford

Case 109, another Massachusetts case, 85 N E R, 858

*Andrus vs State*, another Texas case (281 S W R, 851)

*Harris vs State ex rel Wilson*, Solicitor, an Alabama case (109 So R, 290)

*State vs Price*, an Idaho case (159 Pac R, 1183)

with me to go to the trial, they were decidedly more hopeful, and, as I just related, they won a verdict

"While it does not sound well for a man to tout himself unnecessarily, we might as well recognize the value of my presence at a trial as an expert witness (as well as an advisor) As you probably know, I can qualify to the limit, having worked with the x-rays since 1896 and as a specialist in Chicago since 1907, specializing in therapy, as consultant for several hospitals, member of several x-ray societies, author of many papers upon radiological subjects, etc. Bringing these qualifications to a jury *must have some weight* In addition to this, I know how to testify I make my answers intelligible to the most ignorant man on the jury, explaining in detail whenever the opportunity presents, and generally succeed in convincing the judge and the jury that I know what I am talking about and that I am telling the truth Right here it may be worth while to note that I have treated multiple warts (papillomas) with x-rays with good results I treated one yesterday It can probably be used, without bringing out that my technic was different from yours As a matter of fact, I applied 6 ma for 5 minutes, through 1 mm aluminium, at 100 kvp, at 10 inches F S D

"I wish I were so situated, Doctor, that I could afford to volunteer to come to B without any expense to you, but as your insurance company will pay the bill, that need not deter you if you feel that you want and need my services I can arrange so as to be there at the time of the trial and not be away any longer than is necessary, as the train schedules are most favorable for that Of course, it will be necessary to know when you will want me, a day or two ahead, so that I can arrange my work here My office work is almost altogether by appointment, many appointments being made weeks in advance, and when anything like this occurs, I send word to such patients, giving new dates I would like to come and feel sure that it will be decidedly worth while for you and the insurance company

"Trusting that this puts the subject in a definitely lucid and satisfactory basis, "

Two days later I received the following "It is with great pleasure and relief that I write you of the settlement that has taken place in my case I have no doubt in the world that, from the testimony of both sides, I would have ultimately won, but the undesirable publicity attached to it, as well as the long-drawn-out contentious, exasperating experience, prompted me to follow my attorney's advice, and settle

"The insurance company put up most of the money and I was taxed vastly less than I ever dreamed of In fact, it was lighter than would have been my personal attorney's fee

"I want you to know that I appreciate very much indeed your willingness to serve in the capacity you mentioned in your letter, and I am quite sure that the insurance company would have had you come if the case had come to trial

"Your letter is indeed a most interesting one, and I shall keep it to use in case it might be of assistance to some other poor chap in this part of the country, in case you might not be able to come here "

The foregoing is an example of what occasionally happens The writer has never seen so much that is unusual all occur in one patient, but the unexpected thing is liable to occur to any of us and if we can find a similar case or one nearly akin to it, we may find help, or at least moral support It is exactly this sort of thing that has kept the writer on the trail of roentgen dermatitis malpractice suits, and by keeping in touch with all possible decisions from courts of last resort, he has in enough instances to make it interesting to himself and valuable to the other fellow been able to offer something constructive for the other fellow and destructive to the one claiming malpractice, or trying to get some of the doctor's hard earned money

#### ROENTGEN DERMATITIS FOLLOWING DIAGNOSTIC PROCEDURE

In 1922 a man named L. had a complete



ence to me, but he expressed the desire for money. I knew that the poor fellow had been through a horrible experience, and having some insurance, felt that my insurance company would permit me, under the circumstances, to give him what he asked for, so I requested him to name the sum he wanted. He did so, and signed a release to that effect.

"Some time after this the patient went to Europe, being a German by birth, and on his return a little ulcer showed up on the site of the former irritation. His family physician, seeing the gravity of the situation, suggested that he go to Johns Hopkins, which he did. At that institution they removed the ulcerated tissue, which showed no evidence at all of malignancy, and dissected out the glands on that side of the neck. Following this operation the man had an extensive infection on that side of his neck, which almost caused his death. On his return from Johns Hopkins he entered suit against me on the grounds of fraud, claiming that I had mislead him into a compromise by saying that he was all right, and would have no further trouble, which, of course, is ridiculous, having had some fourteen years' experience in x-ray work previous to that time.

"Anyway, the suit was pushed, the jury was tied up in a six-to-six split, and at the present writing a rehearing will be had on the 5th of next January.

"The insurance company's lawyer, a very capable man, has been very much interested in your articles, and asked me the possibility of getting you to come here to assist in the present predicament.

"Will it be possible for you to lend your assistance on the date mentioned, should I wire you to come? My lawyer is trying to effect a compromise to, if possible, relieve me from the disagreeable and damaging advertisement that naturally follows.

"Please let me know immediately under what conditions you would come."

I replied "After a hasty review of your account of the case I would say that about the only point against you is that the dosage you administered might be considered

somewhat in excess, but with that taken into consideration the effect produced (as you relate it) was certainly very unusual, and was, in my opinion, evidence of marked idiosyncrasy to the effects of the roentgen rays, besides a very marked hypersensitiveness.

"With these things in mind, it seems to me the points that stand out as most vulnerable to attack are first, marked idiosyncrasy to x-rays, second, the late appearance of the dermatitis—after three weeks—suggests to me the possibility of the patient having applied some drug after he had received the irradiation.

"The points which clearly are in your favor are the treatment given was and is a recognized one for multiple papillomas, you settled in good faith with him and have a release, and the ulcer removed at Johns Hopkins Hospital was not malignant (*you should try to secure an affidavit to that effect*).

"In preparing this case, I would direct the attention of your attorneys to the following: *Rost vs Roberts* (Wis), 192 N W R, 38, *Ferguson vs Bellaire* (Iowa), 197 N W R, 13, *Hamilton vs Harris* (Texas), 223 S W R, 533. This last cited case is the second trial and second Supreme Court decision, and in this decision it is stated 'He [meaning the radiologist] is not expected to anticipate results arising from the peculiar characteristics, etc., nor is he an insurer of unexpected results.' Also, *Antowill vs Friedman* (N Y), 188 N Y Supp, 777, *Street vs Hodgson* (Md), 115 Atl R, 27, *Stemens vs Turner* (Pa), 117 Atl R, 992, *Hayes vs Lufkin* (Minn), 179 N W R, 1007.

"I do not think that your case is nearly as bad from the standpoint of the defendant as was the *Rost vs Roberts* case (192 N W R, 38), in which I appeared for the defendant and in which the verdict was for the defendant, and included a judgment of \$550 for his services to the plaintiff. Just before the trial, the attorneys for the insurance company came to my office with long faces and told me that they had a bad one, but when they left, after planning

similar apparatus, which have been discarded and cast aside almost before the ink of their signatures to the releases was dry

The following is an example of this sort of thing, in which the most important testimony was against the presence of any injury, but wherein the defendant corporation chose to pay a considerable sum in settlement rather than run the risk of an unfavorable verdict

A few years ago, a little, scrawny, slant-eyed woman of about 23 years of age was brought to me by an investigator for an attorney for examination of her lumbosacral and pelvic regions

When she entered my office she limped considerably on her *left* leg and walked with a typical guarded spine gait. She was so shift-eyed and fox-like in her conduct that I went into considerable detail in my physical examination of her, and her flippancy and impertinence became so extreme that it was disgusting to both my assistant and myself

After disrobing, she pranced up to the x-ray table without any limp or guarded spine and flopped from dorsal to lateral position as though she was enjoying herself immensely. She hopped down from the high table and put on her clothes, all the while chattering like a parrot that had had a drink of hard liquor. But, *as soon as she had her clothes on she resumed her guarded spine gait and limped on her right leg as she went out*. Her conduct was so bad that it was good—a paradox, but you know what I mean

My report to the attorney read, in effect, that the physical and roentgen examinations of his client's lower dorsal, lumbar, and sacral spine, pelvis, and thighs showed no deviation or departure from normal

Not having discussed why this attorney had sent this woman to me for examination, I was considerably surprised to be called over the telephone a few days later by the attorney and informed that my services as an expert witness would be needed the next day, and that he was sending a formal subpoena for me but that I was to be paid

as an expert by him, in the case of *Miss R vs a certain corporation*. This woman was suing the corporation for \$25,000, alleging that she had received a spinal injury, and I found out later that she had imbibed several drinks with the *investigator for the corporation*, who had brought her to me for examination, and report to her own attorney (I had mistaken the investigator for the corporation to be in the employ of the plaintiff's attorney)

When I was put on the witness stand, qualified, had presented my films, interpreted them, identified the woman as the one whom I had examined and the direct examination was concluded, the defendant's attorney began a quiet and methodical but most searching cross-examination. He asked me about her gait, whether she appeared to be lame, if, in my opinion, she was really lame and disabled. All of my observations, naturally, brought out much that was damaging to the plaintiff's case. Re-direct examination brought out but little more and convinced me that the plaintiff's attorney did not understand my report or he would certainly not have called me as his witness

Because of the allegation of injury and the likelihood of the jury giving a verdict for the plaintiff—in the face of such a poor showing being made by the plaintiff—the defendant corporation decided to settle this case. This was done immediately—out of court—after I had completed my testimony. Evidently they preferred to pay rather than risk it with the jury

I met this young woman, coming into the building where I have my office, the day after the foregoing trial. She walked entirely without limp or guarded spine, as I well knew she could. I remarked to her that her "hip and spine appeared to be much better." Her reply was, "Oh, yes, my case was settled yesterday."

Perhaps I am a cynical old duffer, but I cannot help thinking that it is a crying shame for persons like this to be permitted to do this sort of thing. There was definite and conclusive evidence that the plaintiff

gastro-intestinal examination consisting of two fluoroscopies of unknown duration and five roentgenograms. The roentgenologist, at that time a recent graduate in medicine, estimated the fluoroscopies to have totaled about 3.5 milliamperes-minutes in duration, with 15 inches FSD, 4.5 inch SG, and 1 mm Al filter to the anterior abdominal wall, and about 7 milliamperes-minutes to the dorsal region, with the same settings. The five films were made by using  $1\frac{3}{4}$  sec, 30 ma, 5 in SG, 28 in FD, each with 1 mm of aluminium filtration.

It was found—*after the trial*—that this same patient had had several roentgen examinations at a certain free dispensary where the x-ray work was done by a nurse technician and where no data were obtainable as to dates, time, etc.

Shortly after the examinations described in the preceding paragraph, the man developed a typical roentgen dermatitis, passing through the usual course and at the end of about two months presenting a typical third degree dermatitis. There was a deep ulcer in the lumbar region, containing three central islands of grayish-yellow slough, with angry over-riding edges, etc., so characteristic of the condition.

At this time the man was seen by one of our celebrated dermatologists, who prescribed a paste to be applied (which, incidentally, did about as much good as if the paste had been applied to the asphalt pavement in front of the hospital).

About three months after the advent of the dermatitis the man was moved to another hospital where his treatment consisted of making a complete excision of the damaged area, followed by skin grafting. The operation was most skilfully done by one of our best surgeons and resulted in a very satisfactory healing and termination of the condition.

At this time, a couple of lawyers who had heard about the case from a friend of the patient, visited the latter and had little difficulty in inducing him to allow them to start suit for malpractice, taking the case on a contingent fee basis, they to receive one-third of the amount of the damages awarded.

The case hung around in the courts for nearly five years, and when it did come up for trial the echoes of the Bloomington case (in which the doctrine of *res ipsa loquitur* was held to apply in all x-ray injuries resulting from diagnostic procedures) had not yet ceased reverberating, so the attorneys for the defendant advised settlement. This was accomplished for \$1500.

The writer had been in conference with the defendant's attorneys in the hope and with the idea of helping in the defense, and was very much relieved to learn, just before the beginning of the trial, that it had been settled.

Here was an instance of the plaintiff having had roentgen examinations made both before and after those for which the defendant in the lawsuit had examined him, such unrecorded and unprovable examinations probably contributing largely to the injury (if not entirely being the cause). The young physician who made the examinations and who was later the defendant in the suit, had not questioned the patient as to whether he had had any previous roentgen exposures, and had consequently applied enough to produce the damage to an already insulted skin. It was a costly lesson to him, as he had no insurance, and he had to dig down deep into his pocket to pay the amount he settled for, in addition to his attorney's fees.

#### PROMPT RECOVERIES OF PLAINTIFFS AFTER SUITS ARE SETTLED. HER "CASE WAS SETTLED YESTERDAY"

All those who have had any considerable amount of experience in the adjustment or settlement of claims for damages resulting from personal injuries have observed how rapidly the disabilities, lameness, limping, etc., for which the allegedly injured person has tried (usually with success) to collect damages, are healed, cured and entirely disappear as soon as the financial settlement has been made.

We have seen numerous most remarkable recoveries in instances in which patients (plaintiffs, we better say) required wheel chairs, crutches, jury masts and

jection was made until after I had sent Mr H several bills to his place of business in B. Then he wrote me a complaining letter in which he protested our habit of not sending him the x-ray films. This was the very first that we heard that he wanted the films or copies of the same.

"It is our custom to keep on file in our office all original negatives, because when we release the negatives we are then without any evidence upon which to base our diagnosis. We are willing at all times to loan the films in each and every case. Mr H, on his visit to E, did not come to see us in regard to the matter, and made no demand, written or verbal, to our office for the privilege of seeing the films or borrowing them for his physician's inspection.

"Mr H certainly owes this bill just the same as if Mrs H had taken her son to a store and bought a suit of clothes for him in the absence of his father. Our work was done in good faith and in the best possible manner. We will be very glad indeed to have your representative in B consult the leading physicians there regarding our professional standing and the reasonableness of our fee of \$35.00 for an x-ray gastrointestinal study. Dr E S, a roentgenologist of B, will be pleased to tell you, I am sure, if our charges are reasonable and if our practice of keeping a file of the films is unusual.

"We regret very much to be forced to take the only course left open to us in this matter. With all fairness to Mr H, I would suggest that your representative see him again and try to get him to close this matter by paying the account, but if he refuses to do this we are enclosing our check for court costs and will expect you to proceed according to law, as is our custom in such cases."

So that he might have what he hoped would be a somewhat broader and a more authentic aspect of the situation, this attorney asked Dr E S about the matter, who, after giving his own opinion and approval to all the two high radiological authorities had done and claimed, suggested that he (the attorney) write me rela-

tive to the affair. Consequently I received the following: "Dr E S, who is a member of the same medical association with you, tells me that you would likely be glad to furnish me with information pertinent to a suit I have against a Mr H, of B, for Drs N and N, of E. These latter run an x-ray laboratory in E and also are members of the same medical organization.

"Enclosed you will find copies of letters, etc, which will give you data in the case. Wish you would kindly give me information regarding the customs of x-ray specialists as to what is a reasonable charge, to whom their bills are sent usually, the letting out of films and copies of films, wife contracting debt under the present circumstances, and any other data of recent cases, etc, that would be of benefit to me in winning this case for Drs N and N.

"As the time is very short before the trial, will ask that you kindly forward me this information, if you will, at your earliest convenience. I did not have time to have Drs N and N write you and then send your answer to me."

I immediately replied: "While I do not pretend to be an authority upon the law in the questions you ask, I will give you my opinion in regard to them and will assure you as regard the question of the ownership of the roentgenograms. Several attorneys who have threatened to bring action to force physicians to deliver the roentgenograms to their clients have either withdrawn their action or have stopped any action after being shown a copy of the enclosed reprint entitled 'The Ownership of the Roentgenogram'.

"Your inquiry as to 'what is a reasonable charge,' is entirely too vague and indefinite for intelligent reply by me. I must know more about what was done by your clients before I can answer. A complete gastrointestinal examination would justify charging a fee of from fifty to two hundred dollars, and this would be reasonable enough if any great amount of service was rendered.

"Bills for services rendered to minors should be rendered to their natural parent

was neither lame nor injured. It is, as I have so often repeated, almost impossible for a corporation or rich litigant to secure justice in personal injury suits. The general idea appears to be that "they are rich, let us sting them."

#### AN INSTRUCTIVE FEE COLLECTION CASE

A well-known firm of high radiological authorities in the Southwest rendered services to the son of an attorney in another city in the same State, and failing to be paid their fee after a reasonable time, wrote a letter to the attorney. It elicited the following: "I have a bill from you for \$35.00 for x-rays made of my little boy. My wife tells me that Dr. Q sent her to you to have these made while she was visiting her sister in E in July. Knowing nothing about such matters, my wife did as directed by Dr. Q (*sic*). When I learned that he had directed her to have x-rays made I immediately wrote and asked her to see Dr. Q and inform him that if I was supposed to pay for these x-rays, to send me the films as soon as they were ready, but Dr. Q informed her that they never let the films go out. In my little practice I deal with x-rays frequently and the films are furnished to me on request. As the procedure of Dr. Q developed, he did not impress me favorably and I advised him that his further service would not be desired, and requested his bill.

"The only value an x-ray would have been to me was to learn from physicians here on whose judgment I relied whether they revealed any disorder. Being refused the films at the only time they would have been of service to me, they have been of no value to me whatever. I feel this explanation is due you."

The radiologists immediately replied: "We have your letter of Sept. 7, and in reply will say for your information that your wife brought your little son to us, voluntarily, at Dr. Q's request, for an x-ray study of his abdomen. In making the entry in our case book Mrs. H. was asked by my secretary regarding payment for the service and was told to send the bill to you,

and she was given your business address, to which our bill was promptly sent. Our terms for our service are strictly cash at the time the work is done, but we felt that you were good people, willing to do the right thing, and we did not wish to wound your feelings by holding up the work until your wife could communicate with you.

"When the work was finished we made our regular report to Dr. Q. We were never asked for a copy of the report or for copies of the original films. As an attorney you probably know that roentgenologists are required to keep the original films, because when they release them they have robbed themselves of the evidence on which they have based their opinion. Had you communicated with us we would have been only too glad to have furnished you with supplementary reports and with prints from the original films.

"As a member of the legal fraternity we feel sure that you realize that our time, services, and the material used in an examination represent our merchandise just the same as goods on a merchant's shelf, and when such goods are ordered the obligation is equally as binding.

"We are very sorry indeed that you have had a misunderstanding with Dr. Q and that, because of this fact, you feel that you owe us nothing for our services, however, when you have thoroughly considered the matter we feel sure that you will be conscious of your obligation to us and will promptly discharge the same by sending us your check for the amount of our bill."

Not receiving a remittance after waiting a reasonable period, they (the radiologists) wrote to another attorney as follows: "Confirming our telephone conversation of a few days ago, I am sending you herewith an account of \$35.00, properly attested, against F. D. H., of B. In order that you may better understand the attitude of Mr. H. in this matter, I am enclosing a copy of his letter with a copy of our reply. You will note that Mrs. H. brought their child to our office for an x-ray examination at the suggestion of Dr. Q. of this city. The work was accepted and, as far as I know, no ob-

jection was made until after I had sent Mr H several bills to his place of business in B. Then he wrote me a complaining letter in which he protested our habit of not sending him the x-ray films. This was the very first that we heard that he wanted the films or copies of the same.

"It is our custom to keep on file in our office all original negatives, because when we release the negatives we are then without any evidence upon which to base our diagnosis. We are willing at all times to loan the films in each and every case. Mr H, on his visit to E, did not come to see us in regard to the matter, and made no demand, written or verbal, to our office for the privilege of seeing the films or borrowing them for his physician's inspection.

"Mr H certainly owes this bill just the same as if Mrs H had taken her son to a store and bought a suit of clothes for him in the absence of his father. Our work was done in good faith and in the best possible manner. We will be very glad indeed to have your representative in B consult the leading physicians there regarding our professional standing and the reasonableness of our fee of \$35.00 for an x-ray gastrointestinal study. Dr E S, a roentgenologist of B, will be pleased to tell you, I am sure, if our charges are reasonable and if our practice of keeping a file of the films is unusual.

"We regret very much to be forced to take the only course left open to us in this matter. With all fairness to Mr H, I would suggest that your representative see him again and try to get him to close this matter by paying the account, but if he refuses to do this we are enclosing our check for court costs and will expect you to proceed according to law as is our custom in such cases."

So that he might have what he hoped would be a somewhat broader and a more authentic aspect of the situation, this attorney asked Dr E S about the matter, and after giving his own opinion and approval to all the two high radiological authorities had done and claimed, suggested (the attorney) write me rela-

tive to the affair. Consequently I received the following: "Dr E S, who is a member of the same medical association with you, tells me that you would likely be glad to furnish me with information pertinent to a suit I have against a Mr H, of B, for Drs N and N, of E. These latter run an x-ray laboratory in E and also are members of the same medical organization.

"Enclosed you will find copies of letters, etc, which will give you data in the case. Wish you would kindly give me information regarding the customs of x-ray specialists as to what is a reasonable charge, to whom their bills are sent usually, the letting out of films and copies of films, wife contracting debt under the present circumstances, and any other data of recent cases, etc, that would be of benefit to me in winning this case for Drs N and N.

"As the time is very short before the trial, will ask that you kindly forward me this information, if you will, at your earliest convenience. I did not have time to have Drs N and N write you and then send your answer to me."

I immediately replied: "While I do not pretend to be an authority upon the law in the questions you ask, I will give you my opinion in regard to them and will assure you as regard the question of the ownership of the roentgenograms. Several attorneys who have threatened to bring action to force physicians to deliver the roentgenograms to their clients have either withdrawn their action or have stopped any action after being shown a copy of the enclosed reprint entitled 'The Ownership of the Roentgenogram'.

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## CASE REPORTS AND NEW DEVICES

### RADIOGRAPHS MADE ON THE FLUOROSCOPE

By RAYMOND G. TAYLOR, M.D., Los Angeles

It is frequently difficult to reproduce on the film gastro-intestinal lesions seen on the fluoroscopic screen unless films are made with the patient in position exactly as in screening. In order to simplify this and produce films of what is seen on the screen, we have for a good many years made films of the stomach and duodenum, and, later, an examination of the lower right quadrant, with the fluoroscopic

short life of the tube as a result, this limits one also to a broader focus tube than is desirable for fluoroscopy. To obviate some of these disadvantages we had a double tube holder made and placed on the fluoroscope in place of the regular tube drum. As seen in the illustrations, this consists of a wooden and bakelite frame attached to the trochoscope frame, which carries on a rocking arm, or bar, two ordinary air-cooled radiographic tubes, one of which is a fine, the other a coarser, focus. The rocking arm, or bar, is so arranged that by pulling on the lever *G* (Fig. 1), the far tube is rotated to a

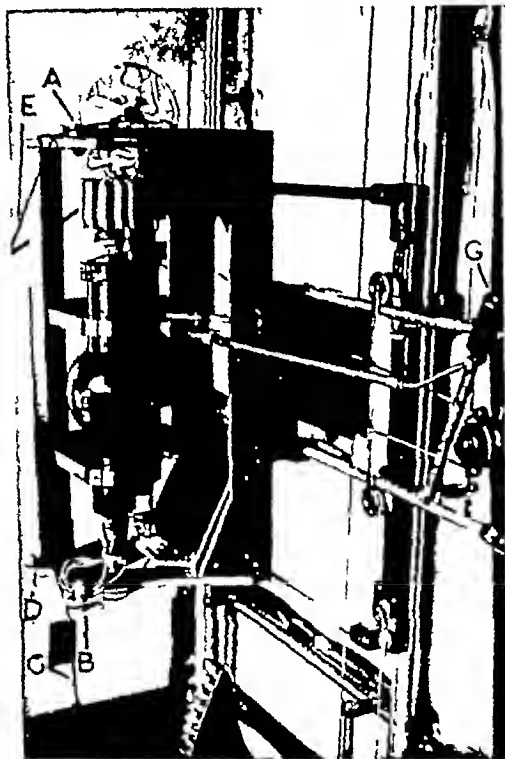


Fig 1

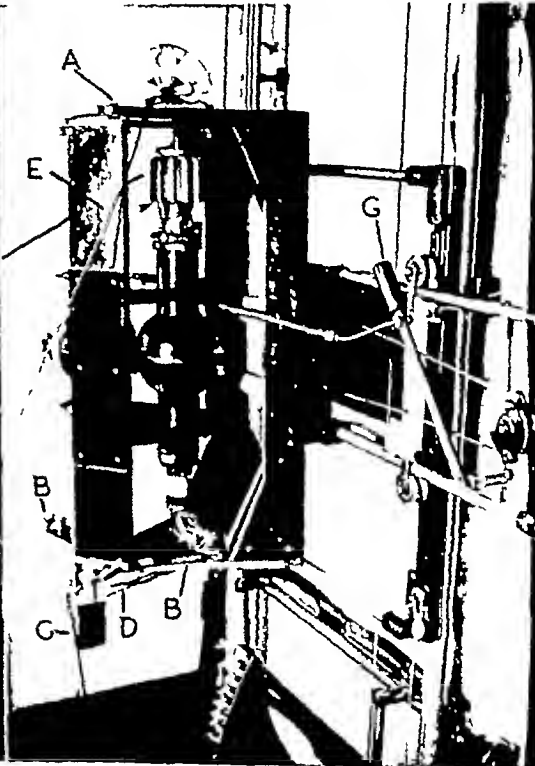


Fig 2

tube. The technical quality of these films has not always been first class due to nearness of the fluoroscopic tube to the object radiographed, and other well-known technical handicaps. Nevertheless, they have been useful from a diagnostic standpoint.

The disadvantage in using a tube both for fluoroscopy and radiography is that the tube gets rather hot simply from the fluoroscopy, and when one adds the heat from two or three radiographic exposures, one brings the tube temperature up to a dangerous point, with

point in front of the shutter on the fluoroscope. Pushing the lever *G* toward the fluoroscope (Fig. 2) puts the other tube in the line with the fluoroscopic shutter. The arrangement is very simple and easy for any one to build. The only thing requiring any mechanism of any consequence is the double knife switch which is shown at *B* in the illustrations. This is a double male and female type of switch made of spring brass and carries the filament circuit. They have to be, of course, insulated from one another, which is a simple matter.



or guardian or to such other legally qualified person if no parent or guardian exists. If the services were rendered to a child, and contracted for by the mother, the father, if alive, would, of course, be liable for the bill, unless he had advertised that he was not responsible for bills contracted by his wife. That would hold good in commercial lines—if the wife bought shoes or pie for the child—and there should be no difference between needful goods and drugs or medical services. Certainly no court or jury would see otherwise. There are dozens of decisions by courts of last resort, applicable to this question. I am enclosing a clipping from a magazine in which a paper of mine is published, which contains several citations which apply here. Am also enclosing reprint of tenth and eleventh installments of a series of papers on "The Law and Medicine" from the same magazine, which contains excerpts from decisions you may find of use.

"I am very much interested in these subjects and would like to have you inform me as to the final outcome of this case, when it is disposed of. Please do this.

"Trusting that my feeble efforts may help my friends in E in securing justice."

I did not hear from the attorney, but one of the men involved informed me verbally that the bill was paid.

While the foregoing may at first glance seem to be an unnecessarily elongated tale, I believe that it is a decidedly worth while lesson in how to collect our fees.

#### "PAYMENT IN FULL" MEANS JUST THAT!

About twenty years ago, the writer rendered services to a family, the head of which was moderately well to do, but who was slightly hard to collect from. A bill in the amount of \$85.00 was sent him. After a considerable time, the debtor sent me a check for \$50.00, accompanied by a letter stating that "the enclosed check is payment in full for services rendered." I immediately acknowledged receipt of the pay-

ment "on account" and sent a receipt, stating that there was a balance of \$35.00 still due me. The check was endorsed by me, "Payment on account, leaving a balance due of \$35.00."

After several months had passed and several unsuccessful attempts had been made to collect the balance, the account was sent to a collection agency. In due time the agency brought suit for the balance due.

At the trial, before a municipal court judge, the defendant's attorney presented a carbon copy of the letter which had accompanied the check and the judge immediately rendered a decision in favor of the defendant in the suit. He (the judge) stated "The tender of the check as payment in full and the acceptance thereof, no matter how the check was endorsed, could not be separated. The acceptance of the check by the plaintiff involved acceptance of the conditions under which it was tendered. The law permits of no other interpretation of the acceptance of the check as payment in full than that it, along with the stipulation, was accepted. Furthermore, acceptance of the check implied acceptance and assent to the terms under which it was tendered, and the endorsement, as testified to by the plaintiff, cannot in any way affect the legality of his acceptance thereof as payment in full."

*The lesson is obvious*

#### I HOLD THE SACK

Five young men were suing a millionaire shoe manufacturer and a large rubber corporation for damages to their hands, resulting from their use of unprotected fluoroscopes which they had used while examining about a million rubber shoe heels.

I examined the hands of all the plaintiffs, preparatory to appearing as an expert witness for them. However, before the time for the trial, the defendants settled all the cases. The defendants claimed that they paid the plaintiffs' attorney for my services. Unfortunately for me, he entirely forgot to pay me, so I was left "holding the sack" and the rabbit got away.

success. It is made entirely of inexpensive parts which are obtainable practically anywhere. It operates on the principle of the

supply the power for both the coil and the filament of the tube through the unusual hook-up illustrated, as the positive high tension

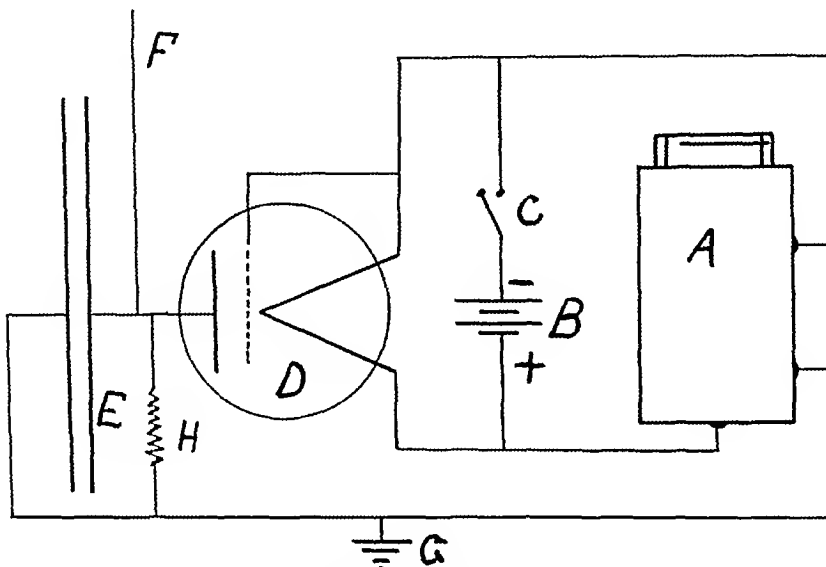


Fig 2 Wiring diagram of the high voltage supply

- (A) Model "T" ignition coil
- (B) Three volts supply two dry cells
- (C) Switch
- (D) Type 30 radio tube
- (E) Condenser 2 microfarads 2,000 volts
- (F) Line to Locher tube
- (G) Ground to metal shield and chassis of set
- (H) Ten megohms resistance

vibrators which are so commonly used in automobile radio sets, a model "T" spark coil, with the vibrator spring ground down to about half thickness, being the transformer. The high voltage is rectified by a Type 30 tube, the grid being connected to the negative side of the filament. Though greatly overloaded, this tube seems to stand up continuously. A two microfarad, 2,000-volt condenser smooths out the current and the 10 megohm resistance has a tendency to steady the voltage. After the vibrator is adjusted, the voltage remains within reasonable limits for many hours of operation. Two new standard dry batteries

pole of the coil is grounded and the entire system raised to a high negative potential. Obviously, the switch must be well insulated or the hand of the operator will receive an unpleasant shock. The entire system must be shielded in a suitable metal container with a properly insulated negative lead through the shield.

105 Rutledge Avenue

#### REFERENCE

- (1) TAFT, ROBERT B. Technical Data Concerning the Geiger Counter. *RADIOLOGY*, June, 1936, 26, 756, 757.

#### A SENSITIVE PORTABLE DETECTOR FOR IONIZING RAYS<sup>1</sup>

B. J. E. MORGAN Ph.D. and ROBERT J. REEVES  
M.D., Durham N.C.

From the Department of Roentgenology, Duke University Hospital, Durham N.C.

Although originally designed for the purpose of tracing and recovering lost radium needles about the hospital, numerous other applications

<sup>1</sup> Accepted for publication July 21, 1936

of this portable Geiger counter apparatus have suggested themselves from time to time. For example, it proves itself of particular value in detecting x-ray "leakage," and in making quantitative comparisons of the efficiency of various arrangements of protective shielding. In this connection, it has been found to give immediate and positive indication of radiation intensities which are so small as to require several days' exposure for perceptible blackening of a photographic film. A five-milligram ra-

*D* is a spring which is attached to the rotating tube bar so that, whichever tube is in active use, the metal fixture to which the spring is attached at the base of the tube bar, rotates off center and tends to hold the tube in position.

*A* represents the bolt on which the tube bar is rotated, *E*, the high tension line on the anode side, and *C*, the high tension line on the cathode side carrying the filament current.

These tubes are enclosed in ordinary black lead glass bowls which afford fairly adequate protection.

A cooling fan is placed on the top of the tube carriage. This plays a current of air on the radiators.

Our tube life before using this apparatus did not average over three months. These two tubes have been in position and taken the entire work of the laboratory, as far as fluoroscopy and radiographs on the fluoroscope are concerned, for over two years, and are still in a very useful condition.

This apparatus can be cheaply built by any good mechanic. In our own set-up we have a remote control switch sitting beside the fluoroscopic table by which change from the radiographic to the fluoroscopic setting and *vice versa* can be obtained by merely turning one switch. This takes care of the filament, voltage, and milliamperage. We are able to vary both somewhat, but find a standard setting gets satisfactory radiographs, for the most part, varying only the time.

Such an arrangement as this, in connection with one of the serial plate changers, which now can be obtained for use in connection with the fluoroscopic screen, makes an ideal arrangement for serial radiographs.

1212 Shatto St

### BATTERY-OPERATED GEIGER-MÜLLER COUNTER WITH A NEW TYPE OF VOLTAGE SUPPLY

By ROBERT B. TAFT, M.D., B.S., M.A., F.A.C.R.,  
Charleston, South Carolina

A Geiger-Müller counter operated entirely from batteries is an excellent instrument for anyone who is interested in the study of small quantities of radio-active material, and, as a detector for lost radium, has many advantages over other types of equipment. As the technical data on an instrument of this kind have apparently not been published, this paper seems to be justified.

Figure 1 shows the complete instrument with the cover lifted. The circuit is essentially the same as that in the A.C. set of the author's (1), the Locher tube is the same, and the first amplifier is a Type 32 radio tube,

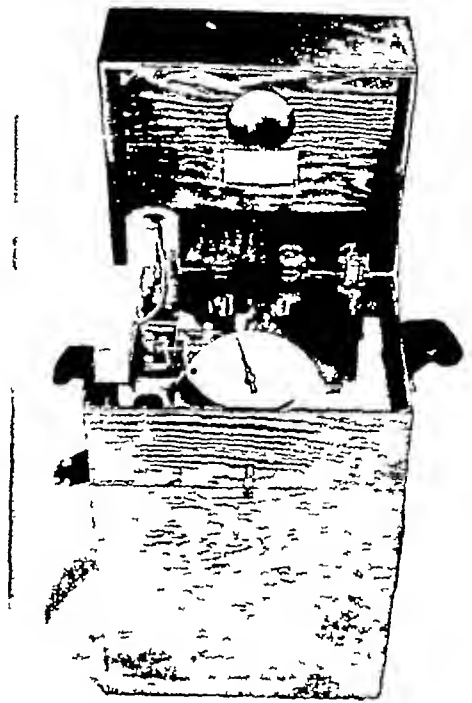


Fig. 1 The battery-operated Geiger-Müller counter in a case with the cover lifted.

the other three being Type 30. The output from the control tube is fed to a sensitive relay of the kind so common in use with photo-electric cells, and the recording counter is the unit from a demand wattmeter. The filaments are supplied by two of the new standard dry batteries, which are approximately half the size of the old No. 6.

Ninety volts of B batteries are used and after some consideration the standard size radio batteries were adopted, though much larger in size and weight, they are of much longer life, quite inexpensive, and, most important of all, easily obtainable even in small towns.

A small neon lamp serves as an indicator for impulses which are too numerous to be recorded.

The source of high voltage for the Locher tube (about 800 volts) is not simple to obtain. Small batteries can be gotten but their expense and short life present some obstacle. The method of charging a large condenser which holds its charge for some time is, of course, an old idea, but the author has not found it satisfactory for use in a hot humid climate, though it was used with fair success during the winter time.

The author's present voltage supply has been in constant use for about eight months, and, during that time, has given complete

sides of the counter gives a distinct directional effect which is valuable in locating lost radium, etc

The unique feature of the circuit, however, is the use of the Geiger counter as an ionization chamber. In the case of intense radiation, such as that encountered near x-ray equipment or appreciable quantities of radium, the ordinary capacity coupled Geiger counter amplifier would become "paralyzed," that is, the bursts of ionization in the counter tube would succeed each other with such rapidity that the counter wire would be unable to recover its normal potential in the short intervening period, and would, therefore, be unable to deliver to the amplifier grid the sharp voltage pulse necessary to cause a "count." This difficulty is overcome by the direct coupling of counter to amplifier, and the use of a plate milliammeter (ma) as an indicator for high intensities of ionization. In operation, the cathode bias control ( $R_2$ ) is set for full scale reading of the milliammeter with the counter voltage turned off. When the high voltage is applied to the counter by closing the switch ( $S_2$ ), a normal rate of about eight counts per minute from cosmic rays, etc., is observed. Each count manifests itself as a sharp click in the speaker and a slight negative swing of the milliammeter needle. When the counting rate is increased by exposure to ionizing radiation, the clicks and associated dips of the meter occur with greater frequency until at a rate of some hundreds per minute, the audible clicks blur into a faint buzz. Before this point is reached, however, the current pulses have become sufficiently rapid so that the resistance-capacity filter around the meter is able to smooth them out into a relatively steady deflection.

The loss of distinct pulses, which are so essential to a pure "counting" circuit, is then of no disadvantage. As the gas within the counter becomes more and more conducting, a corresponding increase of current through the common counter-and-grid resistor applies an increasingly negative bias to the amplifier tube so that the plate current is reduced by a factor proportional to the intensity of ionization.

For use in research, in which case accurate quantitative measurements of small intensities are necessary, a mechanical watch-type recorder incorporating an extra stage of power amplification, for plug-in connection to the main circuit, is now being constructed. In routine radiological work, however, the original design has proved entirely satisfactory.

Except for the Geiger-Muller counter, standard radio receiver parts may be used throughout. A Type 58, or 6D6, tube may be employed

for the amplifier, a 0-1 milliammeter (5-inch size is preferable) for the plate current indicator, a 750-volt, 1,000 ohm-per-volt, meter for the counter potential, and a series-parallel arrangement of 500-volt electrolytic condensers for the high voltage filter. No batteries are necessary. For the high voltage rectifier, a Type 57 tube was employed, connected as a diode, with the control grid used as plate and the screen, plate, and suppressor left floating. In order to make this practical, it is necessary to observe the precaution of allowing the filament to become thoroughly heated before the high voltage is applied. Otherwise, the oxide coating on the cathode will be destroyed and the tube ruined. This high voltage rectification may also be accomplished by the use of one of the commercial rectifying tubes, if the power transformer employed has sufficient capacity to furnish the heavier filament current necessary.

#### SUMMARY

A simple and effective circuit is described, whereby a small Geiger-Muller counter is made to act as a sensitive detector of ionizing radiation, and also as a direct reading ionization chamber for greater intensities. The entire equipment is inexpensive and easily portable, and may be readily used by an inexperienced operator.

### ROENTGENOLOGICAL FINDINGS IN PICK'S DISEASE

#### CASE REPORT

By S A MORTON, M D, Roentgenologist Columbia Hospital, Milwaukee, Wisconsin

Adhesive pericarditis may give rise to a variety of manifestations elsewhere in the body. When it is associated with a recurrent ascites and a large liver, the abdominal manifestations have been given the name of Pick's syndrome. Many writers refer to the whole condition as Pick's disease, and for the purpose of convenience, the name will be so used in this present case report.

The various x-ray manifestations of this condition have been described in different articles on the subject of Pick's disease. The case to be reported is interesting because the diagnosis of Pick's disease was first suggested by x-ray examination. It is also of interest because of the extent of the thoracic findings.

The patient was a boy nine years of age, who was well until four years previous to examination. There is no history of arthritis, tonsillitis, chorea, or heart disease.

Four years previously, the mother noticed that the child's abdomen was enlarging and

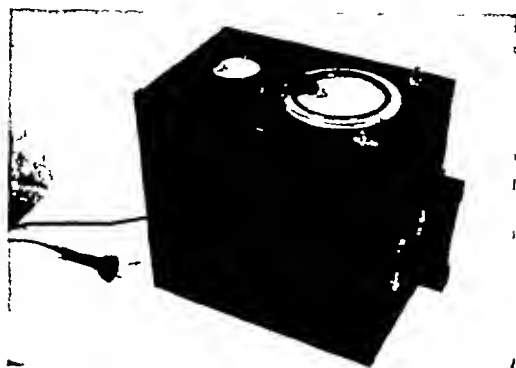


Fig 1

be accurately determined. In the first trial, five days after the patient had received an intravenous injection of 75 c.c. of a colloidal suspension of 25 per cent  $\text{ThO}_2$ , the apparatus was placed in contact with the abdominal wall. The indicated ionization at that time was 82 per cent greater than the normal stray radiation which was recorded after removal from the patient. A series of readings taken at successive intervals will furnish valuable information on the rate of excretion of the thorium from the body. A subsequent report will discuss these methods more fully as further clinical data are accumulated.

The entire apparatus is contained in a small

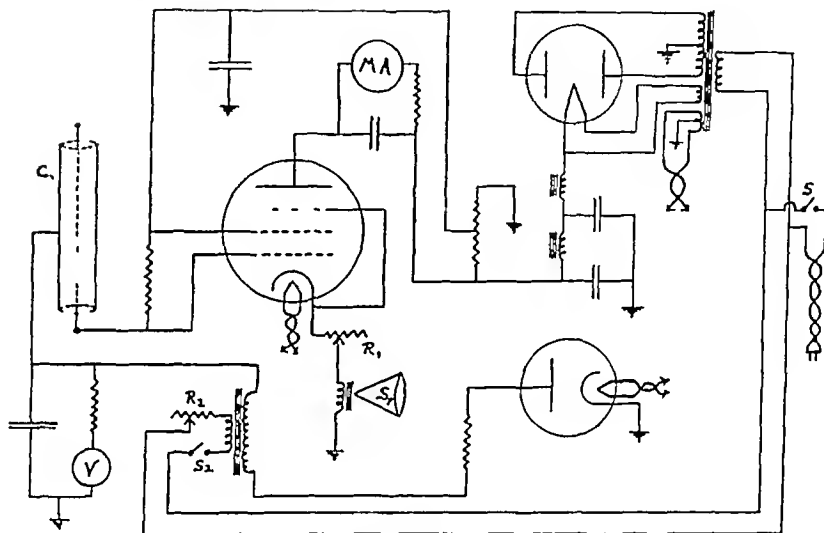


Fig 2

dium needle, enclosed in a half-inch of lead, can be detected immediately at any distance up to ten meters. The radiation from approximately 300 mg of radium has been measured through three inches of lead, a half-inch of steel, and three meters of air.

Actual clinical applications are varied and many problems are yet to be worked out. For many years, the tolerance dosage of x-rays and radium has been roughly estimated by various means, but no method has been accepted as entirely accurate for tissue tolerance. By calibrating the counter apparatus in roentgen units, this can now be accurately recorded by measurement of dosage rate per unit time, and integration of this rate over the total exposure.

The slightly radio-active chemicals, thorium dioxide and hydroxide, which are gradually assuming importance as definite diagnostic aides, can now be detected within the body and their rate of absorption and excretion can

metal case (Fig 1), and has a total weight of approximately twenty pounds. A convenient carrying handle completes the feature of portability, and permits operation over an area limited only by the length of extension cord available from the nearest 110 volt A.C. outlet. The circuit (Fig 2) employs a small Geiger-Müller counter, directly coupled to the single high  $\mu$  amplifier tube. It will be noted that the counter resistor, which also serves as grid resistor for the amplifier, is returned to the screen grid (+150 volts) instead of to the ground. This arrangement tends to decrease the time required for grid and counter wire to return to normal voltage after receiving the negative swing of a counter discharge, and thereby considerably increases the resolving power for individual counts. A small loud speaker (S) in the cathode return lead makes these counts audible as distinct clicks for qualitative indication of the presence of ionizing radiations. Lead shielding on three

chest with a relatively clear space between it and the upper surface of the diaphragm. Because the heart was small and its pulsations were feeble, it was difficult to define its various chambers. The superior mediastinum was very broad for a child and pulsated violently. In the various oblique positions the mediastinum was much more dense than is usually seen. There was no displacement of the esophagus or delay in swallowing.

Examination of the radiographs showed that the bony structures were normal. The upper part of the mediastinum was unusually broad for a child and seemed continuous with the great vessels. In the oblique views the mediastinum seemed unusually dense, and it was possible to demonstrate adhesions between the heart and the pleura on the anterior aspect of the chest. The heart was small and its borders were hard to define on account of adhesions and pulmonary congestion.

Both costophrenic angles were filled up and there was a very marked thickening of the pleura, extending up on the periphery of both lungs as far as the axilla. There was an infiltration of the basal part of both lungs suggestive of passive congestion.

The x-ray evidence of an association of mediastinal and pericardial inflammatory disease, with an extensive thickening of the pleura together with a swollen abdomen, presumably due to a chronic peritonitis, suggested a diag-

nosis of chronic adhesive pericarditis with a polyserositis.

Further examination of the child with this in view revealed dilatation of the veins of the neck and upper thorax. The apex beat could not be felt, and there was a pulsus paradoxus present but no Broadbent's sign. The boy also had a hydrocele in the left side. The electrocardiogram revealed a fixed mediastinum.

No significant finding was noted in the examination of his blood or urine.

The physical signs, together with the x-ray evidence and the history, made a relatively sure diagnosis of an indurative mediastino-pericarditis with a Pick's syndrome and pleuritic involvement.

The patient died following cardiolysis, and postmortem examination confirmed the presence of Pick's disease.

The x-ray plays a definite rôle in the diagnosis of Pick's disease and should be used in all cases. The fluoroscopic observation is exceedingly important, and particular care should be taken to notice the character of the cardiac pulsations and the manner in which the heart behaves during respiration, as well as the clearness of the mediastinal spaces as observed in the various oblique projections.

An unusual feature of the reported case was the marked thickening of the pleura.



Fig 1



Fig 2

Fig 1 Postero-anterior view of the chest taken with about twice the usual exposure time. Note the pleural thickening, the mediastinal widening, the indefiniteness of the heart border and the passive congestion.

Fig 2 Postero-anterior view of the same chest taken with about four times the usual exposure factors.



Fig 3



Fig 4

Fig 3 A right oblique view, showing the mediastinal infiltration and the pleural thickening.

Fig 4 A left oblique view, showing the mediastinal infiltration and the pleural thickening.

that he tired easily. He could not play with the other children on account of shortness of breath. His appetite was good.

He came to the hospital for investigation and a chest x-ray examination was ordered as a matter of routine. The case came to my attention because the technicians could not get a satisfactory plate of the chest even with twice

the usual exposure for a child of this size. Satisfactory plates were obtained with from three to four times the usual factors and the patient was examined fluoroscopically.

Fluoroscopy of the chest was very interesting. The descent of the diaphragm on inspiration was distinctly limited, but what there was of it seemed to leave the heart suspended in the

chest with a relatively clear space between it and the upper surface of the diaphragm. Because the heart was small and its pulsations were feeble, it was difficult to define its various chambers. The superior mediastinum was very broad for a child and pulsated violently. In the various oblique positions the mediastinum was much more dense than is usually seen. There was no displacement of the esophagus or delay in swallowing.

Examination of the radiographs showed that the bony structures were normal. The upper part of the mediastinum was unusually broad for a child and seemed continuous with the great vessels. In the oblique views the mediastinum seemed unusually dense, and it was possible to demonstrate adhesions between the heart and the pleura on the anterior aspect of the chest. The heart was small and its borders were hard to define on account of adhesions and pulmonary congestion.

Both costophrenic angles were filled up and there was a very marked thickening of the pleura, extending up on the periphery of both lungs as far as the axilla. There was an infiltration of the basal part of both lungs suggestive of passive congestion.

The x-ray evidence of an association of mediastinal and pericardial inflammatory disease, with an extensive thickening of the pleura together with a swollen abdomen, presumably due to a chronic peritonitis, suggested a diag-

nosis of chronic adhesive pericarditis with a polyserositis.

Further examination of the child with this in view revealed dilatation of the veins of the neck and upper thorax. The apex beat could not be felt, and there was a pulsus paradoxus present but no Broadbent's sign. The boy also had a hydrocele in the left side. The electrocardiogram revealed a fixed mediastinum.

No significant finding was noted in the examination of his blood or urine.

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# EDITORIAL

LEON J. MENVILLE, M.D., *Editor*

HOWARD P. DOUB, M.D., *Associate Editor*

## PRE-TREATMENT EXPLANATION

Co operation between therapist and patient is a necessary factor in any treatment, especially so in the radiation treatment of malignancy. Ignorance on the part of the layman in regard to radiation therapy is a frequent impediment to co-operation, and precautions should be taken to guard against it.

It is natural enough that the radiologist should have more of a task on his hands in the way of educating his patient than does the surgeon, as we readily realize when we consider the relative ages of surgery and radiology. Radiation therapy being, so to speak, a youngster, has a more limited acquaintance in the lay world than does surgery. When Mrs. Brown goes to the hospital for a surgical operation, it is probable that her next-door neighbor knows someone "who had the same thing done," and has prepared Mrs. Brown for the worst in the way of post-operative sequelæ. The patient's family and the surgeon also expect that a more or less stormy convalescence will follow major surgery, so that, while these effects may cause apprehension for the patient's welfare, they are in some degree taken for granted, and the operation is performed without interference.

Radiation therapy for malignancy is a severe procedure, and certain sequelæ follow. But, unless the radiologist tells Mrs. Brown and her surgeon what to expect, they are unprepared for the post-treatment condition, and, through ignorance, are apt to be unnecessarily alarmed and even interfere with the completion of the treatment planned. To avoid such results, the radiologist should painstakingly explain the reasons for the entire procedure and its results on the skin and underlying internal organs. He should explain them not only to the patient, but to her family physician—the referring physician. Unless he does so, it is small wonder that the patient and her friends become alarmed at the apparently deleterious end-results of the radium or roentgen-ray treatment and are ready to accuse the radiologist of malpractice.

In short, unpleasant relationships between patient and radiologist, as well as unnecessary disappointment and fear on the part of the patient, may easily be avoided by a little pre-treatment explanation.

JOHN T. MURPHY, M.D.

## ANNOUNCEMENT

### THE ANNUAL MEETING

Netherland Plaza Hotel, Cincinnati  
Nov 30-Dec 4, 1936

The Counselors' Dinner, an important annual event with many members of the Radiological Society of North America, will take place at 7 P.M., Monday, November 30.

The Carman Lecture will be delivered at 8 P.M., Tuesday, December 1. Dr. James T. Case, of Chicago, will be the speaker.

The Annual Banquet will be at 7 P.M., Thursday, December 3. The features which render this annual affair one of pleasure to those who attend and of significance to the Society, will all be provided.

## COMMUNICATIONS

### THE SECOND INTERNATIONAL CONGRESS OF THE SCIENTIFIC AND SOCIAL CAMPAIGN AGAINST CANCER

Brussels, Sept 20-26, 1936

When the delegates, approximately four hundred in number, from 42 nations, assembled at Brussels on September 20, they were received and welcomed by His Majesty the King.

The sessions opened at the Medical High School on Monday morning at nine, in six simultaneous sections, and in the afternoon the specially invited general reports were heard in three sections. There were six languages in official use—English, French, German, Italian,

Russian, and Spanish. This arrangement proved rather cumbersome, but was clarified somewhat by abstracted translations in each language of such papers as had reached Congress headquarters in time for printing. Unfortunately, only a comparatively few were thus prepared.

It was a busy week, and every science which has a bearing on the cancer problem was ably presented by leading members of the learned professions from all over the world. Biology came in for a goodly share in the program, and from the United States, Dr. Maud Slye gave some convincing statistics which make one think very seriously of the great importance of heredity in cancer incidence. Cellular pathology and tumor pathology played important rôles in the discussion, and our own Dr. Ewing was the usual master in these ceremonies. Other Americans I had the pleasure of contacting were our good friends Francis Carter Wood, William S. Newcomet, and, from the West, Dr. Payne Palmer, of Arizona, representing the American College of Surgeons. My clinical associates and myself presented a paper entitled "Our Concept of the Management of Cancer Patients by Modern Therapeutic Methods." In the Section on Radiation Therapy, Hermann Wintz, of Erlangen, presented statistics on five-year clinical cures which were highly illuminating and most satisfactory. His article and report evoked a spirited discussion, as his results in cancer of the breast were well above comparable surgical statistics. Later, in talking with Professor Handley, Great Britain's well-known surgeon, we found him in harmony with post-operative radiation but not with pre-operative. This brings up the question, Why are the majority of surgeons opposed to pre-operative radiation? Surely there is enough clinical evidence now established that the cancer cell is more readily killed by irradiation before surgery, trauma, or irritation than later. (See Editorial in *RADIOLOGY*, of March, 1936, page 371.) One of the outstanding reports of the meeting was given by Dr. Dublin, of New York City, concerning cancer statistics and cancer mortality in the United States. It evoked much interest, as did also his resolution that cancer be made a reportable disease—the latter received much favorable comment from the delegates. There was, of course, a tremendous volume of material brought before the Congress which cannot be commented on in this brief report, but which will be made available later in printed form.

The social program was also interesting. The reception tendered the congressionalists and their ladies by the Prime Minister and members of the Royal Cabinet called forth a full representation. There was also a well-attended theater party on a following evening. The closing subscription banquet also brought a full house. It was a colorful ceremonial, with the presentation of distinguished foreign delegates. When Dr. A. Bécclère, our beloved dean of radiologists, was introduced by the toastmaster he was accorded an ovation the like of which I have never witnessed before. He surely is "the Grand Old Man of our martyred science."

In conclusion, your scribe was happy to learn from a great many of our foreign friends that they were planning to attend our Fifth International Congress of Radiology in Chicago next September.

ALBERT SOILAND, M.D., Commander (M.C.),  
U.S.N.R.  
Delegate, Medical Dept., U.S. Navy, to  
Brussels Congress

## INSTRUCTION IN ROENTGENOLOGY

Apropos of the subject of post-graduate teaching in radiology, the importance of the association of anatomical and pathological data in relation to roentgenology is a fact with which no one can afford to disagree, and there is no doubt that further improvement in roentgen interpretation will have to be developed along these lines.

The main differences in opinion seem to be in the method of teaching employed, especially with respect to the place and amount of laboratory work in the curriculum. It appears that the average pathologist, physiologist, or anatomist is not prepared to establish the proper correlation between these branches and radiology. This can be further supplemented with the statement that neither is the student prepared for such correlation without a preliminary course of instruction in the basic principles of roentgen interpretation.

The foregoing also applies to residents, rotating internships, or externs, and even to a considerable number of radiologists, who apply for so-called "refresher" or advanced courses of instruction. All of these appear deficient with regard to the basic principles of interpretation as well as lacking a systematic scheme of analysis from the radiologic aspect.

There is the need for comprehension of aver-

age normal, borderline variations, and development, as well, of basic information with regard to pathologic change as radiologically visualized. There is unfortunately too much clever guessing and comparison with films of so-called roentgen "characteristics."

For the radiologic specialist, the closest of linking with pathologic data is essential. However, the instruction of anatomical, pathologic laboratory work before the basic knowledge of roentgen physics, technic of projection, and the fundamentals of interpretation have been acquired is a mistaken method of procedure. All of this presumes satisfactory medical training, internship, and general clinical experience. The radiologist is studying pathology in the living, which is often quite different from that in the dead body, the inert organ, and the shriveled specimen of the pathologist.

In addition to the foregoing, I will requote a few radiological maxims which convey my idea of the basic principles upon which instruction in roentgen interpretation should be founded, as follows:

*Maxim I*—Roentgen interpretation based on physiologic-anatomic facts is practically a science.

*Maxim II*—Proper application of physico-technical factors based on dynamic, gravitational, and hydrostatic principles approaches 100 per cent accuracy.

*Maxim III*—It is important to remember that color, consistency, cell types, and organisms are not radiologically determinable.

*Maxim IV*—Granting the importance and value of clinical data in the final diagnosis, pure roentgen interpretation is entirely dependent upon gross pathological change with the following information available: (a) Origin, area involved and special predilection, (b) Types of infiltration (gross pathological data), (c) Method of spread (invasion and activity), (d) Physico-anatomic and physiological alterations, (e) Reaction and progress.

Whether the program of instruction be intended for the recent graduate leaning towards radiology as a specialty, or whether it be for the radiologist seeking further knowledge, a thorough comprehension of the material as above outlined is essential before laboratory and research work is undertaken. Whether this be diagnostic radiology or therapy is immaterial.

In the foregoing, there can at best be but a difference of opinion with regard to the method

of approach. The motive and desire to advance the science and art of radiology remain the same.

WILLIAM H. MEYER, M.D.  
Director, Dept. of Radiology,  
New York Post-graduate Medical  
School of Columbia University

## POST-GRADUATE COURSE TUMOR CLINIC

The Journal makes an earnest endeavor to present to its readers information of such educational opportunities as come to its notice. The Editor will appreciate receiving advance information, so that the Journal's readers may attend clinics, conferences, and the like.

The above-named Tumor Clinic was held in Chicago, Sept. 21-27, 1936, sessions being held at the Palmer House, Michael Reese Hospital, and Hines Veterans' Hospital in the suburb of Hines, Illinois. The course was arranged in the form of clinics, lectures, demonstrations, and round table conferences. There was a Breast Tumor Symposium, on which the speakers were Sir George Lenthal Cheatle, Dr. Henri Coutard, and Dr. Max Cutler, a Symposium on Intra-oral Cancer, the speakers being Dr. Coutard and Dr. Cutler, a Symposium on Pelvic Tumors, with the same speakers, and a Symposium on High Voltage X-rays, the speakers being Dr. Arthur Compton, Dr. G. Failla, and Dr. Henri Coutard.

Great benefit was derived from the Clinic by those who attended it.

## MEETING OF ILLINOIS RADIOLOGISTS

The Illinois Radiological Society and the Chicago Roentgen Ray Society held a joint meeting at Starved Rock State Park, Illinois, on Sunday, October 11. In addition to the discussion of several interesting cases the following program was presented:

The Diagnosis of Chronic Cholecystitis  
Dr. W. H. Cole, Prof. of Surgery, University of Illinois

The Illinois Occupational Disease Law  
Oliver E. Mount, Chairman of Committee on Occupational Disease, Illinois Manufacturers Association

## CAMP TRANSPARENT WOMAN

The Camp Transparent Woman was unveiled in New York City in August in the private preview room of the New York Museum of Science

and Industry, in Rockefeller Center, by Dr Dean Lewis, of Baltimore, before a distinguished gathering of noted scientists, leading

contribution to public health education in America

The figure is constructed entirely of a trans-



Fig 1 Left to right Dr Dean Lewis who unveiled the Camp Transparent Woman, Dr Roy Chapman Andrews, Director, American Museum of Natural History, New York City Mr S H Camp of Jackson Mich, who brought the Transparent Woman to the United States as his contribution to public health education

medical authorities, and prominent public health officials Dr Roy Chapman Andrews, Director of the American Museum of Natural History, was also a speaker on this program which was nationally broadcast The exhibit was brought to America, and is loaned by S H Camp, manufacturer, of Jackson, Mich, as his

parent material making every organ, even the veins and circulatory system, as clearly visible to the observer as though he were possessed of x-ray eyes It will be taken on a nationwide public health educational tour of a hundred cities which is expected to last more than two years It will be accompanied by a doctor-



Fig 2 The Camp Transparent Woman the first and only one in the world which will shortly leave the New York Museum of Science and Industry for a nationwide public health educational tour of a hundred cities which is expected to last more than two years. It will be accompanied by a doctor lecturer who will introduce the exhibit to the profession, scientists and public health officers nationally and to the general public in a series of lectures to which admission will be free. At the close of the tour it will be given to some prominent medical school or museum for permanent exhibition.

lecturer who will introduce the exhibit to scientists, the profession, and public health officials nationally, and to the general public in a series of lectures to which admission will be free. Mr. Camp has said that he proposes to donate the transparent figure to some medical school or museum for permanent exhibition at the close of its educational tour, during which

he expects it to be viewed by several million women.

Cellhorn is the substance of which the figure is built. It is important that an exhibit of this kind, to be successful, must be impervious to the normal dangers of changing temperature and travel. Previous attempts, made with a "wax" figure, were unsuccessful because temperature changes caused the figure to lose its perfect proportions.

The Camp Transparent Woman, however, was not brought to America to teach the details of anatomy. Rather, it is a unique and dramatic public health educational exhibit through which the intricate structure and perfectly functioning mechanism of the female body may be seen as a whole for the first time in human knowledge. It is the result of twenty years of laboratory research and was achieved through the combined efforts of the wood carvers, electricians, laboratory workers, artists, sculptors, medical authorities, and scientists of the Hygiene Museum in Dresden. Actually nearly two years were spent in the construction of the present figure. It is exhibited in a heroic pose, arms outstretched above the head. Ethnologically, it might be described as a universal Caucasian type of approximately thirty years of age.

The figure stands on a gleaming round silver mounting in the center of the opaque glass-covered interior of an octagonal walnut wood base. Inside the glass interior are 121 lamps which light up the figure indirectly after each demonstration. Inside the figure itself are 20 sets of two lamps each which light up each organ in sequence while the exhibit is being demonstrated. These lamps were specially constructed for the exhibit and are only four volts each. Thus while the figure is amply lighted for demonstration it will not become overheated. The lamps in the interior of the figure are shaped according to the contour of each organ. As each organ is illuminated, its name is automatically flashed on a glass label on the side of the base. These are in duplicate for the convenience of onlookers.

During its demonstration the brain, from which the skull cap is removed, is first illuminated, then the larynx, thyroid gland, lungs, heart, etc., follow in turn. At the close, the whole figure stands forth in natural colors, fully illuminated from the base. The exhibit, which is ingenious in more ways than one, may also be demonstrated manually so that the

doctor demonstrating it may light up any organ, or any number of organs at the same time. The figure operates on its own motor.

In constructing the Camp Transparent Woman, a series of photographs were first made of normal organs. The negatives of these photographs were then projected on a screen, and from their giant enlargement a series of drawings were made by the artists co-operating in the figure's construction. These drawings are the basis of the sculptors' work in making the moulds for the various parts. During this phase of the exhibit's construction the most detailed supervision was maintained by the medical authorities in the museum, so that each organ and artery is scientifically accurate in color, size, and dimension. After the various sections had been fabricated from cellhorn, a model of the entire figure was made.

Here again all delineations and measurements of the figure received the most careful supervision of the competent authorities. This model is actually a life-size figure in plaster of Paris, based on the scientific measurements of the skeleton, bones, and major organs. From this model the complete cellhorn skin silhouette was moulded. This was cut in half for delicately adjusting the internal sections in their proper places and in accurate relationship to the whole. The upper and lower sections were then joined together, making the Camp Transparent Woman complete in every detail. It is the first Transparent Woman ever made, an artistic, technical, and scientific masterpiece. Even the tiny bones of the ear and the little sesamoids in the thumb and large toe are carefully and scientifically arranged in their proper places.

The Camp Transparent Woman will recall the Transparent Man to the scientific world of America. The first Transparent Man was brought from the same source to the Mayo Clinic, Rochester, Minn., where it is now on permanent exhibition. It aroused the widespread interest of the medical and scientific worlds when temporarily displayed in the Hall of Science at the Century of Progress Exposition, Chicago. The educational authorities of that city arranged for 300,000 school children to see the Transparent Man during the last month of its exhibition there.

Only three other Transparent Men have been constructed. One is in the Hall of Man at the Buffalo Museum of Science. Another was secured for the Swedish Red Cross Museum in Stockholm. The third is in the Hygiene

Museum in Dresden. The Camp Transparent Woman, however, is the only one in existence.

To scientists and the medical world, the Camp Transparent Woman represents a triumph in the history of anatomical study throughout the world, an important milestone in the centuries of world wide research and experimentation which have culminated in our present knowledge of the human body and its functioning.

## IN MEMORIAM

We have the sad duty to chronicle the passing, on Aug 5, 1936, of James A. Hampton Webb, M.D., at his home in Wichita, Kansas. He was an admired and respected member of the Radiological Society of North America, of his county and State societies, and of the American Medical Association. He was a



The late J. A. H. Webb, M.D.

diplomat of the American Board of Radiology, as well.

Dr. Webb began the practice of roentgenology at Stafford, Kansas. Following service as a major in the medical corps in France during the World War, he removed to Wichita, where he remained to the time of his death. He was a member of the staff of Wesley Hospital, and was chief of the department of radiology at the County Hospital.

Dr. Webb was highly respected in his local community and by all who knew him.

## BOOK REVIEWS

**ROENTGEN INTERPRETATION** By **GEORGE W. HOLMES, M.D.**, Roentgenologist to the Massachusetts General Hospital, and Clinical Professor of Roentgenology, Harvard Medical School, and **HOWARD E. RUGGLES, M.D.**, Roentgenologist to the University of California Hospital and Clinical Professor of Roentgenology, University of California Medical School. Fifth Edition, thoroughly revised, 356 pages, illustrated with 243 engravings. Published by Lea & Febiger, Philadelphia, 1936. Price, \$5.00 net.

The Fifth Edition of this popular manual fully sustains the reputation it has achieved as a ready reference for those of lesser opportunity and experience in the interpretation of roentgenographic findings observed in the daily routine. The knowledge gained in a wide experience is succinctly presented, commencing with a comprehensive chapter dealing with those pitfalls of roentgen diagnosis, confusing shadows and artefacts, and offering terse suggestions for their differentiation. In a chapter on fractures and dislocations the authors offer many practical suggestions for the better definition of various types which at times offer considerable difficulty in delineation.

The chapter on bone pathology has been completely revised, particularly in the realignment of the classification of bone changes associated with deficiency diseases, glandular dysfunction and those of somewhat more obscure origin, marble bones, melorheostosis, osteopikilosis, and Gaucher's disease.

In the discussion of the lesions involving the skull and its contents brief reference is made to encephalography and the recognition of suppuration of the petrous pyramids (*petrositis*), but the bibliography following this chapter affords reference to the outstanding literature on these subjects. The subject of spinal cord tumors and backward projection of the intervertebral disc is similarly well covered in the chapter on the spine.

The discussion of the heart and great vessels condenses this subject to embrace the majority of practical methods of determining lesions by roentgenographic or roentgenoscopic examination, including the differentiation of aneurysm from inflammatory or neoplastic mediastinal involvement.

In the chapter on the gastro-intestinal tract the roentgen findings in steatorrhea, sprue,

and regional ileitis are described. Papilloma and adenoma of the gall bladder are included in the discussion of gall-bladder pathology. Retrograde and intravenous pyelography and the interpretation of the images produced in these procedures are well covered in the discussion of lesions involving the genitourinary tract, and hysterosalpingography (uterotubography) is discussed and illustrated. Illustrated with 243 engravings, largely made up of excellent reproductions of roentgenograms, this volume is a worthy addition to the roentgenologic literature.

**RECENT ADVANCES IN RADIOLOGY** By **PETER KERLEY, M.D., B.Ch. (NUI), D.M.R.E. (Camb.)**, Assistant Radiologist, Westminster Hospital, Radiologist, Royal Hospital for Diseases of the Chest, Hon. Medical Editor, "British Journal of Radiology." Second Edition, 322 pages, 176 illustrations. Published by P. Blakiston's Son & Co., Inc. Philadelphia, 1936. Price, \$5.00.

This is a manual presenting the x-ray as a diagnostic method and written in such a way as to simplify the interpretation of radiographs for those of lesser experience and assist in heightening the appreciation of the value of the x-ray among general practitioners.

The subject matter is succinctly and comprehensively presented.

In the discussion of fractures, the simulants, accessory ossicles, sesamoids, patella bipartite, Pellegrini-Stieda's disease, and Schmorl's node in the vertebral body, are interestingly interspersed with practical suggestions for the best visualization of various types of lesion, 'march foot,' or Deutsclander's disease, is differentiated.

In inflammatory diseases of bone, many useful differential points are presented. Under deficiency diseases of bone, pithy, practical descriptions of the various entities are given, and the endocrine disturbances of bone are tersely reviewed. Dystrophies of the skeleton and bone diseases of dubious origin are discussed and classified.

Tumors of bone are presented in a simple and practical classification and differential features are outlined. The chapter on injuries and diseases of joints covers the acute and chronic arthritides, neuropathic arthropathies, hemophilic joints, gout, and groups the various manifestations of osteochondritis in a single category.

The lesions involving the cranium and its

contents, including deformities, are briefly described, and the direct and indirect signs of brain tumor are discussed, including a short but lucid epitome on ventriculography and encephalography. Myelography is also summarized.

In the chapters on the thorax and kymography, the value of the x-ray in the diagnosis of diseases of the heart and the roentgenologic image of the normal heart are discussed in a luminous manner, also the diseases of the aorta and lesions involving the mediastinum. Remarks on bronchiectasis include a description of the various technics used in lipiodol injection. Many practical suggestions are offered for the differentiation of diseases of the lung parenchyma and the better definition of tumors of the lung. Similarly, useful procedures for the delineation and differentiation of pleural effusions are presented, also those for the recognition of eventration of the diaphragm and diaphragmatic hernia.

The chapters on diseases of the alimentary tract contain many practical suggestions and exhibit a wide survey of the literature covering this subject. Cholecystography, retrograde and excretory urography, and hystero-graphy are presented clearly and concisely.

A generous bibliography and a large series of excellent illustrations make this a useful reference manual well adapted to the purpose for which it was written.

**DIE HERZERANKHEITEN IM RONTGENBILD UND ELEKTROKARDIOGRAMM** By DR. MED. PAUL UHLENBRUCK, A. I. Prof. an der Universität Köln, Rhein, Chefarzt der Med. Abt. des St. Elisabeth-Krankenhauses und Deutschen Caritas-Institutes für Gesundheitsfürsorge in Köln - Hohenlind. A volume of 318 pages with 316 illustrations. Published by Johann Ambrosius Barth, Leipzig, 1936. Price, 36 R. M.

Printed beautifully and with abundant, well reproduced illustrations, this volume attempts a correlation between the clinical, roentgenographic, and electrocardiographic findings in a wide variety of cardiac conditions. The technic of cardiac roentgenology and electrocardiography is dealt with adequately. The various diseases of the heart and aorta are then considered by means of well selected illustrative cases. The place of roentgenology and electrocardiography in diagnosis is well described and their relation to each other is established. Roentgenkymography of the heart is briefly described and in some cases its practical use is illustrated.

On the whole, the correlation attempted is adequately accomplished. The volume is essentially one for clinicians and cardiologists. For the roentgenologist there may be too much material devoted to electrocardiography and too little to roentgenology.

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fects Hemoptysis may occur in congenital cystic lung disease

The treatment of congenital cysts should be conservative as long as the patient is symptomless. No giant air cyst should be tapped unless it interferes with respiration because tapping of a giant air cyst may be followed by shock and death. The literature is reviewed and cases are reported.

S. M. ATKINS, M. D.

**Interlobar Pleural Effusions** Barnet P. Stivelman  
*Am Jour Roentgenol and Rad Ther*, October, 1935, 34, 475-481

Interlobar pleural effusion shadows are often misinterpreted. At times they are considered to represent mild and atypical chronic pneumonic processes or are confounded with intrathoracic newgrowth.

Occasionally transudate secondary to circulatory failure may accumulate in interlobar fissures and closely simulate pulmonary consolidation or newgrowth.

Symptoms arising from this interlobar exudate are usually less severe than the lobar consolidation. Physical findings are usually very meager. The leukocytosis is usually less marked in the interlobar effusion than in the pneumonia but the resolution of the interlobar lesion is slower. Lateral roentgenograms are usually the most important in recognizing the interlobar fluid accumulation. The commonest location is between the upper and middle lobes of the right lung but they may occur anywhere, even including the azygos fissure.

J. E. HABBE, M. D.

**Atypical Pneumonia** Frank Kellner München  
*med Wchnschr* Jan 17, 1936, 83, 90-92

Knowledge of this subject is practically entirely dependent upon roentgenologic examination. Many descriptive terms have been employed heretofore viz, central abortive ambulant pneumonia. Since the so called grippe epidemics have been thoroughly studied the conclusion has been reached that this is merely a catarrhal infection of the upper respiratory tract and bronchial tree which in most cases evolves into true pneumonitis of various forms and extent. This fact has not been generally recognized by the profession. The author likewise intimates that probably the great proportion of so termed primary or early infiltrations ascribed to a tuberculous infection is in reality atypical pneumonitis of non specific origin. Serial roentgenographic study will very often clarify this point.

In children it is the rule to find pneumonitis incompletely involving a lobe particularly in the base of the upper lobe as a triangular density with apex directed toward the hilum. Further extension occurs medially and toward the apex. In pertussis there is marked pulmonary involvement in the acute stage which rapidly disappears in the decrement. The appearance of honeycomb like densities along the paravertebral borders extending along the lula to the diaphragm is typical. Measles presents various pulmonary appearances predominantly miliary and confluent bronchiopneu-

monia. In infants it is most difficult to distinguish various forms of pneumonia and it is not uncommon for parenchymal infiltration to be visible for weeks. Thickening of the interlobar pleura frequently is discernible as an aftermath of atypical pneumonitis, rarely are fibrotic strands present in the parenchyma. Important from a practical standpoint is the more careful management in cases presenting atypical pneumonia as compared to the common therapeusis in what is diagnosed as grippe.

WILLIAM R. STECHER, M. D.

**Congenital Cystic Lung** A Report of Multiple Cysts within an Accessory Lobe Moreton J. Thorpe  
*Am Jour Roentgenol and Rad Ther* December, 1935, 34, 724-729

Cystic lung is a congenital developmental anomaly the exact cause of which is not known. The cysts may be solitary or multiple. If enough of the lung or lungs is involved, especially in the presence of infection, it is usually fatal within the first few months of life.

Recurrent attacks of dyspnea and cyanosis, with hyperresonance and displacement of the mediastinum, should suggest a cyst rapidly filling with air. Small multiple cysts, unless infected, may remain silent, when infected, they may simulate bronchiectasis with cough and sepsis.

The cysts roentgenologically are seen to have thin walls although when infected the walls may be thicker from infiltration and accompanying adjacent atelectasis.

S. M. ATKINS, M. D.

**Roentgen Therapy of Primary Carcinoma of the Lung** L. Popovic *Strahlentherapie*, 1936, 56, 141

The author reports four cases of carcinoma of the bronchus which were treated by roentgen rays. One patient remained well for 30 months, one died after eight months, one after one year and the fourth patient—discharged because of the hopelessness of the condition—died two months after treatment. Bronchographic studies are shown in the paper demonstrating either the stenosis of the affected bronchus or defects in the outline of the tree.

**Technic**—A modification of Coutard's method was used. A total of 4,000 r were given over a period of from 20 to 40 days with daily doses of from 70 to 100 r, one anterior and one posterior field. 180 kv, 2 ma, 50-80 cm FSD, 1 mm Cu + 1 mm Al, duration of exposure, 45-80 minutes. No permanent damage of the skin was observed in any one of these cases.

ERNST A. POHLE, M. D. Ph. D.

**Congenital Cysts of the Lung** René Pierret and André Breton *Bruxelles med* May 31 1936, 16, 1172-1189

Congenital cysts of the lung are of three types: solitary large cysts which may be confused with partial or total pneumothorax, multiple medium sized cysts, to be differentiated from emphysematous bullae, lung abscess and purulent pleurisy, and small generalized

## THE KIDNEYS

Renal Adenoma James Carver British Jour Urol September, 1935 7, 229-234

This is a report of a case of an adenoma of the kidney in which both pain and hematuria were present, together with a palpable tumor. A list of published cases with similar lesions is included in the article. Albarán attributes the origin of tumors of this type to islands of displaced and imperfectly developed kidney tubules, with their erroneous fusion. On the other hand Borst contends that they arise from part of the *Nierenanlage*.

D H PARDOLL M D

## LEUKEMIA

Practical Application of General Body Exposure with Roentgen Rays in Polycythemia and Chronic Leukemia Max Sgalitzer Strahlentherapie, 1936 56, 341-350

According to the author general body exposure in polycythemia is superior to local treatment of many small areas. The patients remain free from symptoms for a longer period when using general body exposures. Another advantage is the absence of skin reactions. Technique 170 kv, 0.5 min Zn + 1 mm Al, 150 cm FSD, 25 r per sitting over the anterior and posterior body surface. This may be given over a period of six days. Careful blood studies are essential. The same treatment method is recommended in leukemia except that exposures are given every other day and only for four sittings. In children the author considers the method dangerous and contra indicated.

ERNST A POHLE, M D, Ph D

The Treatment and Prognosis of Leukemia. Particularly the Good Results Obtained in Lymphatic Leukemia Involving the Spleen Only. Iser Solomon Strahlentherapie 1936 56, 526-532

Following a brief discussion of the present status of radiation therapy in the treatment of leukemia, the author describes two cases of lymphatic leukemia which involved the spleen only. Following radiation therapy one patient is alive now 19 years after the first treatment, the other patient has been free from symptoms for the last two years. Solomon believes that this special type of leukemia with involvement of the spleen only responds more favorably to irradiation.

ERNST A POHLE M D Ph D

Lymphatic Leukemic Changes in the Face. E von Felsenbrunn Strahlentherapie 1936, 56, 69

The author observed a case of lymphatic leukemia with most extensive bilateral swelling and edema in the face which developed in a manner very similar to advanced Mikulicz's disease. The patient was not relieved by local x-ray therapy and developed several ulcers on both cheeks and in the chin region. Although high doses had been given the ulcerated infiltrations were subjected again to fractional therapy under heavy

filter (1.0 mm Cu) up to 200 per cent of the erythema dose. The spleen was exposed at the same time. Under this therapy the swellings and edema decreased somewhat in size. (Note of abstractor. A study of the photographs accompanying this article is recommended.)

ERNST A POHLE M D, Ph D

## THE LIVER

Chemical Changes of Proteins *in vivo* during and after Roentgen Irradiation of Liver Tissue. J Heeren Strahlentherapie 1936 56, 88

The author exposed ground liver tissue to roentgen rays. The liver was placed in Ringer's solution and exposed to 180 kv, 5 ma no filter 30 cm distance through a layer of water 3 cm deep. 550 r were given in 19 minutes at 23 cm FSD. Most tissues were irradiated for one and one half some for three hours. After irradiation the N.P.N. was definitely increased. There was no increase in the amino-acids but rather a slight decrease. The effect on the autolysis of the ground liver tissue was not uniform.

ERNST A POHLE M D Ph D

## THE LUNGS

Congenital Cysts of the Lungs Eugene Freedman Am Jour Roentgenol and Rad Ther January 1936 35, 44-52

Congenital air cysts of the lungs are more common than was previously thought. The roentgenologic appearance is variable depending on the number and the size of the cysts.

Giant air cysts commonly produce a pneumothorax like appearance, and if a patient presents the clinical and roentgenologic symptoms of spontaneous pneumothorax without a history of acute onset the possibility of a giant cyst should be considered. In rare instances a giant air cyst may produce the clinical and roentgenologic symptomatology of an obstructive emphysema.

Smaller cysts if numerous produce honeycombed shadows which at times mainly if they are situated in the upper lobes simulate an ulcerative tuberculosis and at other times an extensive bronchiectasis. However in cases of cysts there is no evidence of inflammatory changes around the honeycombed shadows nor of retractive changes in the lung fields, hila, or thoracic cage, as in inflammatory conditions. Minute disseminated air cysts may simulate the roentgen appearance of a disseminated tuberculous process or of a fungus infection. At times smaller congenital air cysts cannot be detected in the roentgenogram, due to thinness of their walls or because they are obscured by overlying organs.

The extent of the roentgenologic changes as compared with the paucity of the clinical symptomatology indicates congenital anomaly. Most of the cysts contain air but there is likely to be a small amount of mucus or cellular material in the cavities. At times they may contain large amounts of fluid and become in

and prominent accentuation of trunk markings, in contra-distinction to silicosis, in which there is epidiaphragmatic emphysema and prominent hilar involvement. The appearance of silicosis is variously described as "snow storm," "sago soup," and of a shot-like appearance. In asbestosis there is a diffuse veil-like increased density with no coarse tumefactions which appear to be hard. In the presence of a double contour of pulmonary markings near the cardiac margin, asbestosis as well as bronchiectasis should be considered.

WILLIAM R. STECHER, M D

**A Few Rare Cases of Pulmonary Lymphogranulomatosis.** Carlos Gil Fortschr a d Geb d Röntgenstrahlen, March, 1936, 53, 246-251

The author reports three cases of lymphogranulomatosis with pulmonary manifestations. Two of his patients were in the fifth decade of life, one in the first. It is very apparent that the roentgen images alone can be extremely misleading and that on their basis exclusively a correct diagnosis of lymphogranulomatosis can hardly be made because of the tremendous variability of anatomic and clinical manifestations. Biopsy and histologic investigation always will be necessary. Blood studies too frequently are unreliable, though an absolute and relative monocytosis is found frequently, while in earlier cases, especially in the juvenile form, a transient lymphocytosis may be observed. The disease may lead to the formation of cavities resembling tuberculosis and of tumor masses resembling carcinoma. The hope is expressed that a biologic reaction characteristic of Hodgkin's disease soon may be developed.

H. A. JARRE, M D

**The Three Zones of Simple Pleural Effusions.** Julius Kaunitz. Am Jour Roentgenol and Rad Ther, January, 1936, 35, 57, 58

In effusions not complicated by consolidation, pneumothorax, or adhesions, there are three zones:

1. A radiopaque zone, made up of a large volume of liquid, displacing the lung upward and casting a dense curved roentgenographic shadow.

2. A radiotranslucent zone, consisting of a moderate volume of liquid, interposed between the lung and chest wall and casting a moderately dense roentgenographic shadow.

3. A radiotransparent zone, representing a film of liquid too thin to cast a roentgenographic shadow. This was proven by demonstrating injected oil in the pleural cavity floating some distance above the density of the apparent superior region of the effusion.

S. M. ATKINS, M D

**Asbestosis.** A. J. Lanza. Jour Am Med Assn, Feb 1 1936, 106, 368, 369

Asbestosis is a pneumoconiosis caused by the inhalation of asbestos dust. It is distinct from silicosis in its pathology and clinically. Asbestos (Canadian) is a hydrated magnesium silicate containing 43 per cent magnesium, nearly 13 per cent water and traces of iron and nickel. Hoffman called attention to the possible

harmfulness of asbestos dust in 1918, but it was not until February, 1927, that asbestosis was officially recognized. This was 27 years after the first fatal case was reported. In 1928 the British Factory Department conducted an investigation and enacted laws for the protection and compensation of the workers against this hazard. Since 1927 there have been eleven fatal cases reported in the United States, eight uncomplicated, and three complicated by tuberculosis. Pathologically, while silicosis is predominantly parenchymatous, asbestosis is mainly interstitial, nor is asbestosis characterized by the nodular formation so distinctive of silicosis.

Clinically, asbestosis presents the same dyspnea on exertion, the same dry cough, and the more or less indefinite physical signs characteristic of silicosis. The patient with asbestosis is apt to have clubbed fingers (not usually seen in silicosis), and he is apt to be pasty-faced and even show a slight cyanosis, while the silicotic patient is apt to be fairly robust looking. All the patients in whom asbestosis was detected were, with one exception, working steadily at their trades. In only one case was roentgenographic evidence of active tuberculosis found, several showed healed tuberculous lesions.

Examination of 126 workers, all of whom had more than three years' exposure, elicited indefinite and inconclusive roentgenographic evidence of pneumoconiosis. Four presented evident pulmonary symptoms and corroborative roentgenographic images. The x-ray appearances are not clear-cut or distinctive, as in silicosis, the shadows are finer, more granular and softer than in silicosis. The asbestosis film gives the impression of ground glass, and there is no nodulation with the consequent tendency of the nodules to coalesce and give dense opaque areas in the roentgenogram.

The shadows occupy the lower thirds, except in far advanced cases. Much more investigation and study of roentgenograms of industrial workers exposed to all sorts of silicate and other dusts are needed before it will be possible to speak definitely on this, the most important phase of the diagnosis of pneumoconiosis.

Associated with exposure to asbestos dust is the occurrence in the sputum and pulmonary tissues of a peculiar formation known as asbestos bodies. It is commonly agreed at present that they are not diagnostic of pulmonary fibrosis.

It is by no means certain that asbestosis progresses after withdrawal from dust exposure, nor does infection seem to be as closely and intimately associated with asbestosis as with silicosis.

CHARLES G. SUTHERLAND, M B (Tor)

**Primary Carcinoma of the Lung.** A Diagnostic Study of 135 Cases in Four Years. Aaron Arkin and David H. Wagner. Jour Am Med Assn, Feb 22, 1936, 106, 587-591

Cancer of the lung is one of the most important pulmonary diseases in persons past 40 years of age. It must always be considered in dealing with cases of lung abscess, bronchiectasis, recurrent pneumonia,

cysts which may simulate bronchiectasis. All are congenital malformations and present simply different degrees of a pathologic process starting as a congenital dilatation of a bronchus.

Anatomically two groups may be recognized. The first of these is the large solitary cyst (balloon cyst) which occurs in about 7 per cent of cases, is as large as a goose egg or a lemon, sometimes including a whole lobe or lung. Usually there are no adhesions. It may occur in any lobe and on either side, most commonly, however, it occurs in the upper thorax and there is either compression of the trachea or displacement to the opposite side, displacement of the mediastinum and atelectasis or compression of limited portions of the lung. When in the lower part of the lung the costophrenic angle is obliterated, the diaphragm is flattened, and pericardial adhesions may be present.

At autopsy it is found to contain air and some mucus. The cyst may be subdivided into sections which may or may not communicate. The wall of the cyst suggests the appearance of a ventricle of the heart. Usually a communication with a bronchus may be established, though in some cases it is difficult to find.

In the second group, that of multiple small cysts (cystic disease of the lung) there is a honeycomb appearance. In a localized area of varying size, most frequently in the base, there are seen many communicating compartments placed side by side and suggesting a sponge with large cavities. At times these cysts are immediately under the visceral pleura, a possible cause of spontaneous pneumothorax.

While cystic disease is difficult to diagnose clinically, roentgenographically rather characteristic changes are noted and these are usually of three varieties. In one, the large solitary cyst in the absence of infection appears as a large clear space, occupying part or all of a hemithorax with flattened diaphragm, obliterated costophrenic angle and the trachea and mediastinum displaced to the opposite side. This clear zone may not be limited by the diaphragm. The lower portion may be somewhat irregular, but the upper border is sharp and definite. Throughout may be seen faint transverse linear markings. Confusion may arise in differentiating such a cyst from either a partial or total pneumothorax.

In the presence of infection the appearance is practically that of a lung abscess. The appearance of a hydro-pneumothorax of variable dimensions but with regular contours and particularly showing no change in serial films speaks definitely for a cyst.

The second variety, that of multiple cysts of smaller size, is likewise somewhat characteristic. These smaller cysts vary in size from that of a pea to that of an apple and are generally grouped in one lobe. Here again two different aspects may be noted. In one, the annular shadows are regular, their outlines are very fine, but clear, and the shadow of one superimposed on that of another because of their different planes. No fluid level or surrounding parenchymal infiltration is noted. In the other the annular shadows are less distinct and may be altered by bands of infiltration

which run through the parenchyma of the lung and darken it. This condition is most readily confused with lung abscess, but usually the absence of infiltration, the regularity, the clarity, and the fineness of the annular shadows all indicate cysts. They may also be confused with large emphysematous bullae. They may at times be visualized by instilling radiopaque material but frequently direct communication with a bronchus is not well established and in such cases the bronchial arborization appears quite limited.

The third type is that of congenital dilatation of the bronchus and here considerable difficulty may be experienced in differentiating between acquired and congenital dilatation. As a rule, congenital dilatations are visible without radiopaque material, while the acquired cannot be seen without it.

The authors believe that thoracentesis is well worth trying as a means of treatment and that, with the development of thoracic surgery, drainage of infected cysts will play a more important part.

JOSEPH DAUKSYS, M.D.

Pulmonary Asbestosis. Walter Alwens. München med. Wchnschr., Nov. 8, 1935, 82, 1797-1800.

The author presents 35 additional cases and an excellent review of the Continental literature on this subject. Inasmuch as pulmonary asbestosis is compensable, all workers in the industries involved should be examined before employment and periodically thereafter. Radiography is necessarily employed for no characteristic clinical symptoms are found and rarely are asbestos bodies found in the sputum. In this series, no associated active pulmonary tuberculosis was detected. Roentgenologic findings are always manifest in workers in this industry of ten years' duration, when exposed to the dust hazard. Clinical symptoms of dyspnea, cyanosis, expectoration without hemoptysis were slight but noted generally in the five to ten year interval and rarely as early as six months. An interesting revelation was that although there is a definite relation between the severity of the process and duration of exposure and concentration of the dust, there was a constitutional factor which governed the degree of reaction of the patient to the irritant. The prognosis in well-defined pulmonary asbestosis is unfavorable, death occurring in approximately one half the time after exposure that elapses in silicosis. Therapy is symptomatic. Removal of the dust hazard has been found occasionally not to influence the further progress of the disease.

A classification of the three stages of asbestosis was well outlined. However, many indefinable intermediate stages occur and important generalizations are formulated as follows. In silicosis the oldest and most discrete lesions are found in the lateral and posterior subpleural regions of both mid pulmonary fields with evidence of regional lymph node reaction, whereas in asbestosis there is a diffuse chronic interstitial pulmonary fibrosis beginning in the basal lung fields, particularly on the right side. Asbestosis presents infraclavicular emphysema, slight hilar involvement



piled in a table Technic 160-180 kv, 0.5 mm Cu + 4 mm Al, 30 cm FSD, 10 × 15 cm field, 200 r, one to three sittings at intervals of from four to six weeks After an analysis of the results of the treatment the author states that roentgen therapy cures at least 50 per cent of these patients The results are particularly good in non purulent cases

ERNST A POHLE, M D, Ph D

## OSTEOMYELITIS

Roentgen Therapy of Osteomyelitis J Palugvay Strahlentherapie 1936, 56, 126

The author treated 63 cases of chronic (35) and recurrent (28) osteomyelitis with roentgen rays Technic 160 kv, 0.5 mm Cu, 40 cm FSD HVL ca 0.83 mm, 2-4 fields, 4-8 days' interval between sittings surface dose 50-150 r, depending on the age of the patient The results of the treatment were as a whole very encouraging If a recurrent process was treated in the early stage, it healed without requiring further surgery The chronic stage can be shortened by proper treatment Osteomyelitis in the acute stage should not be irradiated but operated on

ERNST A POHLE, M D Ph D

## PEPTIC ULCER

Pyloric Off-centering a Radiologic Sign of Gastro duodenal Ulcer Albert Chapuy Arch d Mal de l App Digestif, May, 1936, 26, 534-543

Chapuy presents a pathognomonic sign of gastric or duodenal ulcer namely, the placing off center of the pylorus in relation to the axis of the antrum In a normal stomach the pylorus is always in the symmetrical axis of the antrum and it may be very readily determined by observation with no mechanical aids having the patient stand squarely facing the front If the patient is turned slightly to the left, a false off-center observation may result and if to the right the stomach may mask the pylorus Greater dependence is placed on fluoroscopic observation than on films Questionable cases rarely arise and these are chiefly those in which the pylorus is placed behind the antrum when a proper relationship cannot be established and also in cases in which there is a high grade retention with pyloric stenosis Possibilities of error are first using the bulb and not the pyloric canal in relation to the antrum as a landmark second in long atonic stomachs with vertical displacement in cases in which the peristaltic movement cannot be readily traced and third the author observed one case of a tumor of the lesser curvature which gave this sign At the same time however, a large defect was observed and the diagnosis was apparent The author quotes Struan who found the pylorus off center in 19 of 34 duodenal ulcers and in 8 of 14 gastric ulcers The sign is of no value in localizing an ulcer and he has never observed it in non ulcerative lesions Due to the fact that some retention has been found in all cases showing this sign he believes it a prognostic index of pyloric stenosis and uses it as an indication for operative interference

JOSEPH DUKES M D

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The leukopenic index as a method of specific diagnosis of allergens causing peptic ulcer is based on the discovery of Vaughn that milk caused a leukopenia in patients subsequently found to be sensitive to milk Certain foods producing allergic symptoms are able to depress the total leukocyte count, while compatible foods in general are followed by a rise in the total count A positive balance indicates compatible foods, a negative balance indicates allergens The method, though admittedly tedious, appears to be accurate to a high degree

The author reports six cases in which a diet composed of compatible foods exclusively proved capable of giving complete relief from ulcer symptoms and freeing the patient from medication from interval feedings, and from the necessity of hospitalization

CHARLES G SUTHERLAND, M B (Tor)

The Roentgen Diagnosis of Small Gastric Ulcers in the Region of the Cardia C W Lohmann Röntgenpraxis, January 1936, 8, 11-15

The author's experience in ulcers of the stomach situated close to or in the cardia has shown him that their typical localization is predominantly on the posterior wall and about an inch below the cardia They may be shown best by means of the relief method (niche and star-like deformity of mucosa) Re-examination after a short interval is always necessary to check them Changes in size and disappearance of the niche after medical treatment are the best proofs for correct diagnosis Small cardiac diverticula and pseudoniches may lead to errors

H W HEFKE, M D

Gastric Ulcer with Fatal Hemorrhage in the New-born Ralph H Kunstadter and Eugene Gettelman Jour Am Med Assn Jan 18 1936, 106, 207-209

A brief review of the literature discloses 64 reported cases of ulceration of the gastroduodenal mucosa during the neonatal period These classified these as ulcerations associated with melena neonatorum Berglund found 14 duodenal ulcers four gastric ulcers, and one combined duodenal and gastric ulcer in 1323 postmortem examinations of children up to 13 years of age Of his patients, 70 per cent were in the first year of life In 56 cases there were hemorrhagic erosions Dietrich found 134 ulcers or scars of ulcers in 8534 postmortem examinations six of these in children less than 10 years of age, and one of them in an infant aged 10 days Dunham and Shelton reported a case of multiple gastric ulcers in a new-born infant

Mills recently reported a case of multiple gastric ulcers with hemorrhage in an infant six days old revealed at autopsy This infant first presented gastric intestinal symptoms on the fourth day Blood in the vomitus and stools was first noted on the last day of life

In Michael Reese Hospital, over a 20 year period seven cases of gastroduodenal ulcerations were found in



empyema hemorrhagic pleurisy, and chronic pneumonia. Pain in the chest or in other parts of the body accompanied by a cough and bloody sputum and sooner or later followed by dyspnea is the cardinal symptom. An area of pulmonary infiltration or atelectasis enlarged supraclavicular or axillary lymph nodes, a hemorrhagic pleural effusion, paralysis of a diaphragm or of one of the vocal cords, a Horner syndrome and evidence of bone, brain, liver or other metastasis make the diagnosis quite certain. Tuberculosis is usually easily excluded but may occasionally accompany lung carcinoma.

The roentgenologic signs are diagnostic in a high percentage of cases. The bronchoscope is of great value in confirming the diagnosis and in treatment. The finding of carcinoma in a biopsy from an enlarged lymph node, cervical or axillary, a bronchus, tissue in the sputum, sediment from a pleural effusion, or a piece of tissue obtained by thoracotomy completes the diagnosis. All carcinomas of the lung are bronchiogenic in origin. They arise in the trachea, bronchi or bronchioles. There can be no primary carcinoma in the alveoli as they have no epithelial lining. There are three types of carcinoma: (1) adenocarcinoma, (2) squamous cell, and (3) undifferentiated round or spindle cell. Some tumors may arise from the mucus-secreting glands of the bronchi. The round and spindle cell carcinomas were in the past often erroneously diagnosed as lung or mediastinal sarcomas.

In the experience of the authors lung cancer was one of the most frequent causes of osteoclastic bone metastasis.

Of 135 cases studied over a four year period 74 were confirmed by necropsy, 26 by biopsy and 13 by bronchoscopy. Twenty-two were diagnosed from the characteristic clinical and roentgenologic manifestations.

CHARLES G. SUTHERLAND, M.B. (Tor.)

## LYMPHOGRANULOMA

Roentgen Therapy of Lymphoblastoma. R. Gauducheau. *Strahlentherapie* 1936 56, 407-412.

The author briefly discusses 10 cases of lymphoblastoma which came under his observation. Five involved the tonsillar region, three the nasal sinuses, two the cervical and supraclavicular areas. In the last two patients the primary focus could not be definitely determined. Whenever the presence of a lymphoblastoma is suspected  $2 \times 400$  r (200 kv, 1 mm Cu) are given prophylactically followed by biopsy. If the biopsy is positive, from 2,000 to 3,000 r are added per field. Three of the patients discussed in the article are still alive. Two of these have remained free from recurrence for a period of 10 and 12 years respectively.

ERNST A. POHLE, M.D., Ph.D.

Destructive Doses in Roentgen Therapy of Lymphogranulomatosis. Nandor Ratkoczy. *Strahlentherapie* 1936 56, 325-336.

The author believes that Hodgkin's disease is a chronic inflammatory infectious disease caused by some unknown fungus similar to actinomycetes. He recom-

mends therefore, roentgen therapy in high doses applied according to the fractional dose method. Technique: 170 kv, 0.5 mm Cu + 1 mm Al, 50-60 cm FSD, 12 r per minute, 200 r per day per field up to 2,000 r per area. He admits that occasionally the daily dose has to be reduced to 50 r and the interval sometimes has to be changed to two days. The author does not believe in prophylactic irradiation. During the intervals between roentgen therapy, As and liver extract should be given. While these destructive doses will not cure Hodgkin's disease, they are recommended by the author because they may permanently destroy the involved glands.

ERNST A. POHLE, M.D., Ph.D.

The Lymphomatoid Diseases (the So-called Lymphoblastomas). E. B. Krumhaar. *Jour. Am. Med. Assn.* Jan 25 1936 106, 286-291.

Though the typical forms of a number of obscurely caused disorders of the lymphatic and hematopoietic systems, mostly associated with blood changes and tissue enlargements, are distinct in no group of diseases, there are so many variations of individual cases with overlapping into another category and perhaps even transition from one disease to another.

With the inauguration of modern hematology several criteria were accumulated for the segregation of typical cases of the various leukemias, the picture of lymphosarcoma was definitely outlined in 1893 and the establishment of a special pathologic history gave an adequate diagnostic basis for most cases of Hodgkin's disease.

A number of other more or less obscure conditions such as pseudoleukemia, leukosarcoma, granuloma fungoides, Mikulicz's syndrome, the chloromas and more recently the reticulosos and giant lymph follicle hyperplasia, present either such obvious relationships to the group or such difficulties of differential diagnosis that they may well be grouped together under one heading.

The author suggests grouping all these under the non-committal and relatively brief title of the lymphomatoid diseases. The classification and the individual diagnoses as far as possible should be on a pathologic basis. An analysis of 150 cases brought out various items of etiologic and pathologic interest.

The lymphomatoid diseases are practically all alike in having a fatal prognosis, though the duration may extend from a few days to many years. With few exceptions they are peculiarly susceptible to and improved by radiation treatment. The relative resistance of the reticulosos to radiation may prove useful in segregating this group.

CHARLES G. SUTHERLAND, M.B. (Tor.)

Roentgen Therapy of Lymphogranulomatosis Inguinalis (Nicolas Durand Favresche Disease). D. Negru. *Strahlentherapie* 1936 56, 298-304.

During the last 11 years the author has treated 40 cases of lymphogranulomatosis inguinalis. 30 could be followed up and are used for statistical evaluation. The results obtained in the individual cases are com-

piled in a table. Technic 160-180 kv, 0.5 mm Cu + 4 mm Al, 30 cm FSD, 10 × 15 cm field, 200 r, one to three sittings at intervals of from four to six weeks. After an analysis of the results of the treatment the author states that roentgen therapy cures at least 50 per cent of these patients. The results are particularly good in non purulent cases.

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Mills recently reported a case of multiple gastric ulcers with hemorrhage in an infant six days old revealed at autopsy. This infant first presented gastric intestinal symptoms on the fourth day. Blood in the vomitus and stools was first noted on the last day of life.

In Michael Reese Hospital over a 20 year period seven cases of gastroduodenal ulcerations were found in

infants under one year of age two of them younger than one month

The authors report two cases of persistent hematemesis of fresh blood with the onset occurring within the first thirty-six hours after birth

CHARLES G. SUTHERLAND M B (Tor)

## THE PHARYNX

Roentgen Therapy of Hypertrophy and Focal Infection of the Lymphatic Ring in the Pharynx R Torres Carreras and P B Sola Strahlentherapie, 1936, 55, 279

The authors have irradiated the tonsils in 147 patients with "focal infection." This comprised a group of patients with chronic tonsillitis focal infection and swollen glands, pharyngitis enlargement of lumen glands, laryngitis, abscesses, rheumatism, circulatory disturbances disorders of the digestion, kidney disease blood disease and patients with symptoms of focal infection after tonsillectomy The total doses given per area (left and right angles of jaw) amounted to from 300 to 3,000 r, the field size varied from 12 to 48 sq cm, according to the age of the patient. Six sittings were usually given at intervals of three or four days for the first four, and 14 days before the last two The authors believe that a new series can be given from six to twelve months later Of the 132 patients who responded to the treatment, 15 were not benefited Numerous schematic drawings of the pharynx before and after treatment are shown in the article

ERNST A POHLE M D, Ph D

## PNEUMOTHORAX

Medico-thorax—A New Method of Pneumothorax Therapy Wilhelm Müller Schweiz med Wchnschr Feb 29 1936 66, 225-227

The author employs antiseptic-laden air in lieu of the ordinary air in artificial pneumothorax therapy An apparatus for producing this admixture is described, the important antiseptic constituent being trypanflavin This method effectively prevents pleural exudation as is commonly noted in ordinary pneumothorax procedures By absorption of the medicament locally and generally, there is increased rapidity of healing of the tuberculous process, as is noted in rapid subsidence of fever and disappearance of positive bacilli The method is intimated to be a veritable *sterilisatio magna* of the lung

WILLIAM R. STECHER M D

Roentgenologic Demonstration of Pleuritic Bands in a Pneumothorax. Karl Hohenner Röntgenpraxis January, 1936, 8, 1-11

Since the introduction of artificial pneumothorax and of the endoscopic cutting of adhesions it has been of great importance to be able to determine the extent and location of pleural bands in order to use these new methods Fluoroscopy and films are necessary to get

an accurate picture Films in at least two directions are usually necessary to determine the exact location of a localized adhesion which may be cut by endoscopy The adhesive bands which are of greatest importance in this respect are usually situated in the upper portions of the chest and are amenable to a correct roentgen interpretation

H W HEFKE, M D

Pneumothorax in the New-born J van Ebbenhorst Tengbergen Fortschr a d Geb d Röntgenstrahlen, March, 1936, 53, 240-245

This is a report of three cases of pneumothorax in new-borns, with an extensive review of pertinent literature The three children recovered.

The assumption that in large fetuses with abnormal twisting of the umbilical cord, premature efforts at respiration occur and lead to a pulmonary trauma must be regarded as debatable

H A JARRE, M D

Post-operative Massive Collapse of the Lung Josef Meese Röntgenpraxis March 1936 8, 173-176

An atelectatic collapse of a lung or portion of a lung is due to bronchial obstruction In the case of post operative collapse, hypoventilation and formation of mucus and secretion, with decreased expectoration, is probably the most common cause. The roentgen signs are typical a dense homogeneous opacity of one or more lobes, elevation of the diaphragm and displacement of the heart and mediastinum toward the diseased side. Shrinking of the involved lung and edema are responsible for the x ray findings

H W HEFKE, M D

The Increasing Importance of Pneumothorax Therapy in Pulmonary Tuberculosis J W Cutler Jour Am Med Assn, April 18 1936, 106, 1366-1373

Artificial pneumothorax was suggested as a form of treatment for pulmonary tuberculosis by James Carson, in England in 1821, but until recently collapse therapy has made relatively little progress in this country

Pneumothorax has been regarded as a sanatorium procedure the recognized indications were narrow, and the number of cases comparatively few With the rapidly increasing application of all forms of collapse therapy therapeutic pneumothorax is now probably overdone.

Intensive local rest for an indefinite time only can control the toxemia and its constitutional manifestations and this can best be accomplished by collapse therapy This shuts off the source of the toxemia and further absorption of toxic products is eliminated For this reason the immediate results of artificial pneumothorax are often dramatic

Experience has shown that in a majority of cases from three to five years is necessary to effect a cure and in some cases longer Pneumothorax should be continued for at least a year after the x ray evidence indicates complete healing

Artificial pneumothorax must be regarded as a public health measure of the first magnitude

Improvement in technic has materially increased the usefulness of artificial pneumothorax and widened its indications. Contra-indications are hypertension and heart disease or cardiac decompensation. As a rule, patients beyond 50 years are easily upset when the intrapleural pressure is changed by pneumothorax therapy. Extensive adhesions contra-indicate pneumothorax, but such patients may be helped by phrenicectomy or thoracoplasty.

Complications are air embolism, pleural shock, pleural diffusions, spontaneous pneumothorax, and disease in the contralateral lung, and these are discussed in detail.

CHARLES G. SUTHERLAND, M B (Tor)

## THE PROSTATE

Leiomyoma of the Prostate Gland. Frank S. Patch and Lawrence J. Rhea. *British Jour Urol*, September, 1935, 7, 213-228.

The authors find that leiomyomatous nodules are frequently seen in association with adenomatous enlargement of the prostate. They report an incidence of 25.4 per cent in a series of 181 consecutive cases examined. This high percentage may be directly attributed to their method of examining the prostate and the differential staining employed. A reproduction of the urinary tract with its associated pathology, as well as several photomicrographs of the gland sections in this case are presented.

D. H. PARDOLL, M D

Prostatectomy with Closure. Addenda and Some Observations. S. H. Harris. *British Jour Surg*, April, 1936, 23, 816-819.

The author makes some observations on the procedure of prostatectomy with closure which he recommended some two years ago. There are certain modifications which have been introduced and which should be beneficial to surgeons employing this method.

DAVIS H. PARDOLL, M D

A Large Leiomyoma of the Prostate. T. M. Munpriss. *British Jour Surg*, April 1936, 23, 863-865.

The author reports a case of leiomyoma of the prostate which weighed 19 ounces. Reproductions of the tumor and microscopic sections are included in the article.

DAVIS H. PARDOLL, M D

## RADIATION EFFECTS

A Contribution to Total Teleroentgen Therapy. L. Siciliano. *Strahlentherapie*, 1936, 56, 351-353.

The author briefly discusses the history of general body exposure which was inaugurated by Dessauer in 1905 and revived by Teschendorf in 1927. He suggests for economical reasons to divide the body surface in two or three parts rather than to treat one surface at a

time at long distance. The treatment will consume less time if more areas are used. He accepts the rationale of general body exposure in leukemia but cannot quite agree to its use in Hodgkin's disease. He does not irradiate normal glands but only those which are definitely involved. In polycythemia, he also objects to the use of general body exposure because only the bone marrow should be treated and not the spleen. As a matter of fact, its function should not be disturbed in this disease.

ERNST A. POHLE, M D, Ph D

Some Biological Results of Roentgen Therapy of the Hypophysis. A. Lambadarides. *Strahlentherapie*, 1936, 56, 273-277.

The author relates his experience with roentgen therapy directed to the hypophysis in 22 women suffering from ovarian dysfunction, in some menstruation had stopped and some of the patients never had menstruated before. Technic: 180 kv, 3 ma, 50-60 cm FSD, left and right temporal area, 5 × 5 cm, 0.8 mm Cu + 2 mm Al. During a period of from several weeks to three months, a total of 2,000 to 2,400 r was applied. The results were most gratifying. The author also treated with the same method several men aged over 50 years, their general condition and potency improved (?).

ERNST A. POHLE, M D, Ph D

Contribution to the Treatment of Ischias. Walter Altschul. *Strahlentherapie*, 1936, 56, 181-183.

The author recommends as the best method of radiation therapy of ischias a combination of roentgen therapy to the roots and injection of radium chloride to the nerve. He uses one or two fields, applying 200 r, filtered through 4 mm Al. Fourteen days later six injections of from 1 to 2 mc of radium chloride, administered daily, are given. This method is, in the author's opinion, superior to diathermy.

ERNST A. POHLE, M D, Ph D

The Problem of Dosage in Radiation Therapy. Ralston Paterson. *Strahlentherapie*, 1936, 56, 478-487.

This is a critical analysis of the physical part of the problem of dosage in radiation therapy: quality, quantity, and intensity of radiation.

ERNST A. POHLE, M D, Ph D

Modification of Radiosensitivity by Means of Readily Penetrating Acids and Bases. R. E. Zirkle. *Am Jour Roentgenol and Rad Ther*, February, 1936, 35, 230-237.

Using the spore of the fern *Pteris longifolia* and also *Paramecium*, it was noted that an increase of the acids carbon dioxide and hydrogen sulphide up to a certain concentration increased the radiosensitivity and beyond that point, a decrease, while the base ammonia acted in the reverse manner. These chemicals produced no detectable effects without the irradiation.

Clinical application of the above results depends

upon whether mammalian tissues will respond in the same way, both to the chemicals and to irradiation, and also whether such response will be without harm to normal tissue

S M ATRAINS M D

## RADIOLOGY, PRACTICE OF

Plato and the Radiologists T Rees München med Wchnschr April 24 1936 83, 671-673

The author recounts the classical tale of Plato in which the people could see only the shadows of personages and when one was freed to see the actual person he was amazed and dismayed, considering the shadows to be really the actual entity. A simile is cleverly drawn to roentgenologists, who are students of "shadow pictures." Great stress is placed upon reliance not only upon pure roentgenologic evidence, but history, and evaluation of signs and symptoms. This is most important in gastro-intestinal roentgenology in which such confusing and seemingly divergent diagnoses are established upon the same person upon successive days of examination. Excellent illustrations of this are given, and in the case of the ulcer niche the author suggests the possibility of a blood clot or inspissated mucus filling the ulcer crater, which would prevent its visualization. The author recounts interesting stories of radiologists one of whom deplored the fact that without a modern rotating target roentgen tube and high powered equipment proper examination was impossible even in regard to such a common examination as that of the gall bladder. Unquestionably the trend of to-day is toward greater refinement and advancement in the technical equipment of radiology rather than toward a more thorough knowledge of the fundamental pathologico-anatomical concept of disease.

It is of great importance not to make an unqualified dogmatic diagnosis especially in gastro enterologic work when a re-examination is feasible. In concluding he warns that we as radiologists as in Plato's shadow fable, must strive to become aware of our inherent limitations in pure roentgen diagnosis and the greater the scope of one's radiologic acumen becomes the more cautious one is, in arriving at a conclusive diagnosis.

WILLIAM R STECHER M D

## RADIUM

Radium Content of Rocks W D Urry Jour Chem Phys, January 1936 4, 40-42 (Reprinted by permission from Science Abstracts Sect A Physics Feb 25 1936 No 458 p 133)

The determination of the age of common rocks by the helium method necessitates accurate measurements of the radium content. The method of compensating the background by the use of two opposed ionization chambers is applied to radium determinations and the apparatus has an observational limit of  $5.5 \times 10^{-14} \times n^{-1/2}$  gm radium for  $n$  hourly readings. With the Th

content determined as above results for a suite of rocks from a single horizon and the present status of a geological time scale are given

AUTHOR

Excitation of  $\gamma$  rays by Neutrons (Part II) S Kikuchi K Husimi and H Aoki. Phys Math Soc. Japan Proc January, 1936 18, 35-49 (In English) (Reprinted by permission from Science Abstracts Sect A Physics April 25 1936 No 460 p 363)

The  $\gamma$  rays emitted by proton neutron interaction are observed. The cross section for the process is found to lie between  $1.0-0.36 \times 10^{-28}$  sq cm. The energy of the  $\gamma$  ray quantum emitted by this interaction is determined by the method of coincidence of two counters and is found to be  $(2.2 \pm 0.1) \times 10^6$  eV. The absorption curves of the secondary electrons due to  $\gamma$  rays excited in Cd, Cl, Cu and Fe by slow neutrons are also determined. In the case of Cd, Cu and Fe  $\gamma$  rays of more than  $1 \times 10^6$  eV in quantum energy were observed.

AUTHORS

Radio activity of the Atmosphere G Aliverti Gerlands Beitr z Geophys 1935 46, 223-226 (In Italian) (Reprinted by permission from Science Abstracts Sect A Physics Feb 25 1936 No 458 p 133)

The results obtained by the author's apparatus have to be corrected by factors 1.10 and 1.17 for D.C. and A.C. respectively. This agrees for D.C. with the work of Illing and Malek using a similar apparatus but their correcting factor for A.C. is 1.99. To test the accuracy the author uses two consecutive identical pieces of apparatus and comes to the conclusion that (except for radon) there are no radio-active atoms in the atmosphere. He points out the sources of error in Illing and Malek's apparatus and concludes that his own gives a quick and sufficiently accurate measurement of the radon content of the air.

H M B

Contribution to the Technic of Radium Therapy in Carcinoma of the Cervix by Means of Exteriorization of the Small Pelvis Frans Daels Strahlentherapie 1936, 56, 380-388

The author has developed an operative technic which permits exposure of the pelvic organs so as to make possible irradiation of its entire volume by means of distributed radium screens. Human serum is poured in the pelvis following laparotomy in order to keep the peritoneum in good condition for 20 days or longer. During that period the radium applications are carried out. So far the mortality has amounted to 10 per cent, the author is hopeful however that this can be reduced. While no statistical evaluation of the method can be given Daels is convinced that it is superior to vaginal and cervical application of radium.

ERNST A POHLE M D Ph D

Radium Therapy of Carcinoma of the Cervix from 1923 to 1934 J W F Heukensfeldt Jansen Strahlentherapie 1936 56, 249-258

The author presents a statistical analysis of 371 pa

tients with carcinoma of the cervix. The radium technique used followed that of Regaud. Roentgen therapy was given only if there appeared to be parametrial involvement. On from 12 to 14 successive days there was given a total dose of 800 r over one anterior and one posterior field. More recently this dose has been increased. The statistical data are compiled in four tables and one graph. It is concluded that out of 371 patients with carcinoma of the uterus, 148 remained free from symptoms for a five-year period, which corresponds to a 35.1 per cent clinical cure. The primary mortality amounted to 3.2 per cent if all deaths were included.

ERNST A. POHLE, M.D., Ph.D.

Properties of Radio-active Series. E. Lopoukhin. *Phys. Zeits. d. Sowjetunion* 1936, 9, 27-33 (In French). (Reprinted by permission from Science Abstracts, Sect. A, Physics, May 25 1936, No. 461, p. 488.)

With the help of recent models of the nucleus it is shown that the series of radio-active elements exhibit three consecutive phases of disintegration. In addition to these certain other formal conditions are established for determining the course of alpha or beta disintegration.

N. M. B.

Yield of Emanation from Radium-bearing Rocks to Flowing Water. H. Maché and G. Markstein. *Akad. Wiss. Wien. Ber.*, 1935, 144, 2a, 7-8, 489-492. (Reprinted by permission from Science Abstracts, Sect. A, Physics, Feb. 25 1936, No. 458, p. 133.)

The paper describes experiments carried out to test how the quantity of emanation given up by a solid radio-active material to flowing water depends on the concentration of emanation in the water, the temperature of the water, and the grain size of the material.

W. E. P.

Recrudescence of Ovarian Function after Heavy Irradiation. Two Cases. George Van S. Smith. *New England Jour. Med.* April 9 1936, 214, 725-727.

The author reports two cases of cyclic uterine bleeding following 2,400 and 6,000 milligram hours of radium, respectively. Biopsies revealed functioning endometrium and thus a recrudescence of ovarian function. The author gives these findings as presumptive evidence for the development *de novo* of ovarian follicles after a long period of quiescence.

W. H. GILLETINE, M.D.

Apparatus for Direct Determination of Radon in Water and Air. F. Behounek. *Phys. Zeits.* March 15 1936, 37, 203-208. (Reprinted by permission from Science Abstracts, Sect. A, Physics, May 25 1936, No. 461, p. 490.)

The paper first describes apparatus for determining the concentration of Rn in water. The sample is drawn into a vertical cylinder (0.25 l.) which is connected with the ionization chamber through a tap and a small tube. The water is atomized as it emerges from

the tube and the expelled emanation is drawn into the ionization chamber. The latter is connected to a Lindemann electrometer, provided with a projection system, the scale of which is calibrated in Maché units, two ranges 0 to 70 and 0 to 700 Maché units being available. A portable apparatus incorporating a Lindemann electrometer and a compensating device is also described for the direct determination of Rn in samples of air.

W. E. P.

Measurement of Small Quantities of Radon. H. Garrigue. *Jour. de Physique et le Radium*, February, 1936, 7, 107-109. (Reprinted by permission from Science Abstracts, Sect. A, Physics, No. 461, p. 489.)

The author describes a light, portable, and robust apparatus for measuring the Rn content of air. The air is introduced into a previously evacuated cylindrical vessel containing an insulated charged rod. The fall in potential of the rod due to the ionization produced by the Rn is measured by a small Coulomb balance.

W. E. P.

An Automatic Apparatus for Direct Determination of the Radon Content of Radio-active Waters to be Used for Therapeutic Purposes. F. Behounek. *Strahlentherapie*, 1936, 56, 361-365.

The radio activity of water is usually measured by the gamma ray method. While this is a fairly simple procedure, one has to wait several hours before the decay products of radium have reached a state of equilibrium. It also requires at least 10,000 Maché units in the water to be examined. The customary radio active bath, however, does not contain more than 200 to 1,000 of these units, consequently the use of this measuring method would require large quantities of water. The author has constructed, therefore, an apparatus which permits the determination of from 2-700 Maché units within 10 minutes. Several ionization chambers are connected to an electroscope, allowing for a wide range of radio-activity. The radon content is determined directly in the vaporized water. The apparatus and its manipulation are described in detail, several diagrams illustrating the construction.

ERNST A. POHLE, M.D., Ph.D.

Gamma ray Therapy of Tuberculous Peritonitis. O. Chance. *Strahlentherapie* 1936, 56, 33.

The author treated patients with tuberculous peritonitis with either gamma rays or radium or roentgen rays. Radon tubes (50-70 mc.) distributed in 20 tubes with 0.6 mm. Pt filter are arranged on a felt mold 1 cm. in thickness and 12 cm. in diameter. Three or four fields are given over the anterior abdomen with from 9 to 12 mcd. per area. This produces a very mild erythema on the skin. Of the 42 patients treated, 31 received one, 7 two, 3 three, and 1 four exposures.

The roentgen technique was as follows: 180 kv., 6 ma., 40 cm. FSD, 1 mm. Cu (H.V.L.  $\text{Cu} = 1.54 \text{ mm.}$ ) 200 r. surface dose per field once a week for eight weeks. This series may be repeated at intervals of three months.

While the testicles in men and if possible, the ovaries in women are protected during irradiation there is still danger of sterilization with this type of treatment. In only one instance did amenorrhea occur but menstruation was re established after eight weeks.

An analysis of the results is given only of 42 cases treated with radium. Twenty nine (69.05 per cent) were alive from one to five years following treatment. Compared with statistics giving the end result following operation and light therapy, these figures are very encouraging. As advantages of the radium therapy the author lists the following: equally good or better results as from other treatment methods, duration of treatment only from three to six days, a repetition necessary in a few cases, treatment can be given in the hospital where the patient was admitted for diagnosis, the patient may remain in bed and improvement is noted usually much quicker than after roentgen or ultra-violet therapy.

ERNST A. POHLE, M.D., Ph.D.

## THE RECTUM

Roentgen Therapy of Carcinoma of the Rectum Surgically Exposed for External Treatment. H. Chaoul. *Strahlentherapie*, 1936, 56, 377-379.

At the surgical clinic of the University of Berlin a method has been developed within the last few years which permits the direct surface treatment of carcinoma of the rectum by roentgen rays. Following colostomy the tumor is exposed by opening the rectum in its length and sewing it into the sacral wound. Treatments are given daily according to Chaoul's method (relatively low voltage, F.S.D. of 5-8 cm). The daily dose varies between 400 and 500 r. This is continued until the tumor has disappeared—in the average case it requires a total dose of from 10,000 to 15,000 r. If after two or three months' observation there is no recurrence, the colostomy is closed again. During the last two years, eight patients have been treated in this manner. All were inoperable except one borderline case. In five, the tumor disappeared, one has a residual mass and two are still under treatment. The first two patients treated are still well now after a two year period.

ERNST A. POHLE, M.D., Ph.D.

Intrarectal Radiography (Method, Apparatus, Technique, Indication and Results). B. Sabat. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1936, 53, 143-165.

This is the description of a rectoradiograph, which permits the unfolding of a rolled-up film 45 X 50 millimeters in diameter in the rectum under the protection of an inflated rubber balloon. A correct exposure is ascertained by a centering device exposures being made either postero-anteriorly for study of the coccyx or in the opposite direction for study of some of the pelvic organs.

This paper is illustrated by 68 very excellent reproductions, most of them showing anomalies and patho-

logic conditions of the coccyx among the latter chiefly various types of fractures and dislocations of the coccygeal vertebral segments injury to the coccygeal synchondroses, paracoccygeal ossifications and calcifications disfigurements and deformities of the coccyx, hyperostoses, osteophytes and deforming spondylitis, furthermore changes of the spongy structure which in some cases is limited to extremely small areas infection with small abscesses and sequestration in the bones dermoid cysts, pressure atrophy, etc.

All this information is of great value in the differential diagnosis of the troublesome *coccydynia*. Inasmuch as no two coccyges are alike, the method has criminologic value for identification of individuals. The rectoradiograph is quite an ingenious device which should find a ready field of application in this country, especially as it might also be applied to a number of other investigations, including investigation of various organs during surgical procedures.

H. A. JARRE, M.D.

## RICKETS

Multiple Intracerebral Foci of Calcifications. W. Müller. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1936, 53, 30-34.

This report concerns a rachitic dwarf afflicted with a severe epilepsy, who had also suffered a serious cranial trauma eight years prior to his death.

Multiple, densely grouped intracerebral calcifications were observed particularly in the nucleus caudatus, putamen, pallidum, and in the nucleus of the cerebellum. They could not be explained on the basis of arteriosclerosis but represented capillary and periarterial calcifications up to the size of cherry pits. The etiology could not be elicited but a connection was thought of between these calcifications and previous severe rickets which might have led to a general disturbance of calcium metabolism.

H. A. JARRE, M.D.

## ROENTGEN-RAY BURNS AND INJURIES

The Treatment of Radiodermatitis and its Malignant Complications. H. Bordier. *Strahlentherapie*, 1936, 56, 205-214.

The author discusses the various types of injuries following irradiation differentiating those appearing after treatment and those appearing as a professional injury. In their treatment he recommends diathermy in fatty tissue medical diathermy in other tissue for instance face hand and leg, electrocoagulation. Dressings are applied with a gauze saturated with 1 per cent phenol and changed daily. The wounds are rinsed with 1 per cent phenol plus 7% NaCl solution. All lesions with malignant degeneration are thoroughly coagulated. Some authors have also seen good results by the appli-

cation of infra red rays, however, the author prefers diathermy

ERNST A. POHLE, M.D., Ph.D.

## ROENTGEN-RAY THERAPY

The Heat Effect in Short Wave Therapy H. Korb *Strahlentherapie*, 1936, 55, 686

The author describes a quartz benzol thermometer which can be used for temperature measurements on the skin and inner organs during electric short wave therapy. It appeared that with a wave length of 4.2 meters, when applying the electrodes over the bladder, the temperature within the bladder increased from 37.6° to 38.25° C. A further increase to 38.35° led to a burning sensation. The highest temperature was recorded after from eight to eighteen minutes. The body temperature as measured under the tongue increased from 38.8° to 37.2°. This shows that considerable local increases of temperature cannot be expected, undoubtedly due to the fact that the circulating blood prevents overheating.

The author states emphatically that short wave therapy should not be used in malignant tumors and quotes two illustrative case reports. A special table suitable for treating the pelvis is briefly described.

ERNST A. POHLE, M.D., Ph.D.

## SARCOMA

Radiation Therapy of Sarcoma, Particularly of Bone Sarcoma. Grashey, Glauner, and Meese. *Strahlentherapie*, 1936, 56, 234-248

During the period of 1928-1933, 39 cases of sarcoma were treated at the Roentgen Institute of the University of Cologne. Twenty eight involved soft tissues. One patient is still alive after three years, one after four years, and three after five years, with lesions as follows: a round-cell sarcoma in the cervical region; a spindle-cell sarcoma of the thigh; melanosarcoma of the toe; fibrosarcoma of the arm; and a mixed cell sarcoma of the antrum. This corresponds to a three year cure of 17.7 per cent and a five-year cure of 10.7 per cent. All diagnoses were verified by biopsy. Of 11 treated cases of sarcoma of the bone, two remained well for five years. Brief case histories of these patients are appended. Doses as high as 5,700 r to the tumor and 2,100 r to the regional glands were given. From their observations the authors conclude that simple removal of the sarcoma followed by intense roentgen therapy is at present the best method of treatment.

ERNST A. POHLE, M.D., Ph.D.

## SILICOSIS

Trinoli as a Source of Silicosis. Carey P. McCord *Jour. Am. Med. Assn.*, March 14, 1936, 106, 913, 914

Trinoli (rotten stone) designates a form of silica much

used in industry. It is widely described as amorphous, but at least some varieties are crystalline, although the crystals are so minute as to warrant the term "cryptocrystalline." Trinoli, when air dried in lamps, is a light, fine-textured, minutely porous rock, the individual grains approximately 0.0004 inch in diameter and consisting of 99 per cent silica.

It is rarely the cause of clinical silicosis. In experimental investigation it readily produces proliferative reactions when injected into the peritoneal cavity of guinea pigs. In all respects the responses obtained are similar to those produced by quartz or amorphous silica, similarly introduced. The electrostatic charge of trinoli particles, which tends to the formation of small clumps or masses of this suspended dust, may in some measure contribute to the low order of atmospheric dustiness in trinoli work places, and consequently to the low incidence of silicosis from this substance.

CHARLES G. SUTHERLAND, M.B. (Tor.)

## THE SINUSES

The Radiologic Investigation of the Superior Maxillary Antrum. E. H. Shannon *Jour. Am. Med. Assn.*, Feb. 22, 1936, 106, 599-601

Pathologic processes of inflammatory type within the antrum manifest themselves in several ways: by production of pus, by thickening of the mucoperiosteum, by polypoid degeneration or cyst formation, and by reaction changes in the bony walls. These processes may be identified with considerable accuracy in "plain" x-ray films. The use of iodized oil is rarely necessary and may completely obscure a valuable indication of disease, the condensing osteitis seen in cases of chronic suppuration and the rarefying type commonly associated with chronic polypoid degeneration of the mucous membrane.

An estimate of the accuracy of the method is attempted as checked by the results in 296 patients in whom the radical antrum operation was performed.

Chronic maxillary sinusitis in even repeated subacute infections may fail to cause local symptoms and may remain unsuspected, even though productive of systemic symptoms from direct absorption of toxins or by secondary infections in the joints, the chest, or elsewhere.

Transillumination may be negative even in the presence of an antrum full of mucoid material or polyps. The antrum may be more brightly illuminated on the diseased than on the normal side, probably because of coincident decalcification of its walls. An old healed infection cannot be distinguished by transillumination from one that is recent or active.

The radiologic examination of the maxillary antrum is seldom necessary in the presence of an acute infection. Initially there is a slight decrease in brilliance of all the sinuses. With pus formation a more or less uniformly



dense shadow is produced which almost obliterates the superimposed skull markings if drainage is completely blocked. With incomplete drainage the antrum may be partially filled with exudate with air overlying.

Differential features of examination in the prone and erect positions are informative. Reactive changes in the antral walls should provide a clue as to the presence of pus. One must at times rely on this as the sole means of differentiating between empyema and retention cyst as between an antrum containing polyps and one that harbors both polyps and pus.

In chronic suppuration the marked degree of condensing osteitis is typical of the condition.

CHARLES G. SUTHERLAND, M.B. (Tor.)

## THE SKULL

Hereditary Occurrence of Enlarged Parietal Foramina. Their Diagnostic Importance. O. H. Perry, Pepper and Eugene P. Pendergrass. *Am. Jour. Roentgenol. and Rad. Ther.* January, 1936, 35, 1-8.

The parietal bone frequently exhibits near its upper posterior angle a minute pinhole foramen through which an emissary vein passes. This parietal foramen is very often wanting and, when visible, may be closed. Sometimes it may be double. At times it may be markedly enlarged and can then be palpated and shown roentgenologically.

Clinically the anomaly is of only slight importance although the defect might be found and misinterpreted. It is shown by the authors' cases and the literature that this anomaly is hereditary and although not common is not very rare.

S. M. ATKINS, M.D.

Histologic Control of Roentgen Images in a Case of Tumor of the Epipharynx. L. Kraus. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1936, 53, 114-121.

In the case of an advanced carcinoma of the epipharynx, roentgen studies of the temporal bones and of the sella turcica were compared with serial histologic sections. It was shown that essentially the roentgen demonstration of the destruction and invasion was quite correct and only minor inconsequential detail was not observed roentgenologically, of the latter one might mention a small area of local sclerosis in the floor of the sella. Incidentally this paper well illustrates the value of well done Stenvers projections. Furthermore it should stimulate workers especially roentgenologists to more frequently compare autopsy material with their roentgen records and interpretation.

H. A. JARRE, M.D.

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The Roentgen Diagnosis of Tumors of the Spinal Cord. E. Busch and H. Scheuermann. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1936, 53, 107-114.

This paper contains a confirmation of the work of

Elsberg and Dyle. (See roentgen ray diagnosis of spinal cord tumors by Cornelius G. Dyle in *Diagnostic Roentgenology*, by Ross Golden, Thomas Nelson and Sons, New York and Edinburgh, 1936.)

The distance of the vertebral pedicles was found to be a reliable localizing sign in 10 meningiomas out of 17 reviewed in seven neurinomas out of 11, and in three cases of intramedullary glioma. In several additional cases important conclusions also could be drawn from a study of the structural appearance of the pedicles especially in cases of extradural tumors. Myelography could not be dispensed with in a number of cases and in an additional series was utilized as an excellent means of confirmation of the diagnosis. However, this procedure should not be utilized and interpreted in a discriminately as it could be misleading.

H. A. JARRE, M.D.

## THE STERNUM

A Case of Congenital Bifid Sternum. E. Kewesch. *Röntgenpraxis*, February, 1936, 8, 100-101.

This is a report of a case of congenital bifid sternum involving the manubrium and corpus. The ensiform process was absent, there was a congenital scar in the middle of the abdomen between the end of the sternum and the navel which indicated an anomalous development of the abdominal wall.

HANS W. HEFKE, M.D.

## THE STOMACH

Giant Rugæ (Localized Hypertrophic Gastritis) Resembling Carcinoma. John L. Kantor. *Am. Jour. Roentgenol. and Rad. Ther.* February, 1936, 35, 204-207.

Two cases of giant rugæ (localized hypertrophic gastritis) are described and the roentgen appearance illustrated. Both cases showed resemblance to carcinoma of the greater curvature yet both were proved to be benign at operation.

In the presence of similar roentgen findings the differentiation between carcinoma and hypertrophic gastritis may be made by repeated roentgen observations, with careful correlation of clinical findings. However in certain instances exploratory operation may nevertheless prove unavoidable. Exploratory operations may be minimized in the future by better acquaintance with the clinical pathologic, and especially with the roentgen manifestations of advanced localized hypertrophic gastritis.

S. M. ATKINS, M.D.

Roentgen Therapy for Ulcers of the Stomach and Duodenum. R. K. Kruglikova, M. L. Katscher, and M. L. Awissor. *Röntgenpraxis*, March, 1936, 8, 179-182.

Over two hundred reports about roentgen therapy for gastric and duodenal ulcers are to be found in the literature, some of them are favorable, some of them

declare it useless. The authors have treated 46 cases. Pain, nausea, vomiting, hyperacidity, etc., disappeared very soon or became much less, shortly after roentgen treatments. A mild diet was maintained during and for a few months after treatment. The action of the rays on the ulcer is probably complex (decrease of secretion, anti-inflammatory action, specific influence on the nervous system). Three treatments were given (160 kv) to the stomach, two anterior and one posterior, each consisting of one-third of an erythema dose. After two weeks the series was repeated. In 31 of the 39 cases, the gastric acidity decreased (determined by gastric lavage). The authors are of the opinion that roentgen therapy is a valuable method of treatment for gastric and duodenal ulcers.

H. W. HEFKE, M.D.

Two Cases of Diverticulum of the Cardiac Portion of the Stomach. Ledoux-Lebard, P., Hillemand, Garcia Calderon, and W. Aubrun. *Arch. d. Mal. de l'App. Digestif*, May, 1936, 26, 527-533.

Two cases of diverticulum of the stomach, both near the cardiac orifice of the stomach and placed anteriorly, were discovered in routine examination of patients who had postprandial distress accompanied by profuse intestinal hemorrhage. The pathology was best seen in the lateral prone position.

Of interest is the speculation of the authors, based on studies of the stomach forms of different animals (to be published later) that the gastric diverticulum of the cardiac portion of the stomach may possibly be an abnormal survival of a characteristic normal in the phylogenetic series.

JOSEPH DAUKSIS, M.D.

## THE SUPRARENALS

Histological Changes in the Suprarenals Following Roentgen Therapy. R. B. Engelstad. *Strahlentherapie*, 1936, 56, 58.

The author reviews the literature regarding the effect of roentgen rays on the suprarenals. Because of the discrepancies in the reported findings he undertook a series of investigations of his own. Thirty-one rabbits were exposed to roentgen rays, five animals served as controls. Technique: 170 kv, 4 ma, 0.5 mm Cu + 1 mm Al, 27 cm FSD,  $3 \times 4$  or  $4 \times 6$  cm field size from 125 to 4500 r. At varying intervals following the treatment the animals were killed and the suprarenals studied histologically. After doses just below the skin tolerance (1500 r) very few changes could be demonstrated in the cortex. There was occasional hyperemia, lymphocytic infiltration and very few nuclear injuries. After higher doses which produce a definite epidermitis the degeneration of the cortical cells was definite. 17 or 18 days after a dose of 3000 r these changes are to be found in almost the entire cortex. As far as the time element is concerned, no definite changes could be found during the first two weeks after the treatment. After 15 days beginning degeneration was apparent

accompanied by hyperemia, and this was fully developed after 17 or 18 days. The reaction seemed to reach its peak in the second month and then to recede slowly, followed by fibrosis.

ERNST A. POHLE, M.D., Ph.D.

## SYPHILIS

The Lag Phase in Early Congenital Osseous Syphilis. A Roentgenographic Study. Norman R. Ingraham, Jr. *Am. Jour. Med. Sci.*, June, 1936, 191, 819-827.

The author selected 131 out of a group of 258 syphilitic pregnancies for study, to determine the time interval or lag between fetal infection and the earliest roentgen demonstration of congenital osseous syphilis. He found that the earliest an osteochondritis can be recognized is about five weeks after the fetus becomes infected. A longer period, approximately four months, is required for the development of a syphilitic periostitis.

HENRY K. TAYLOR, M.D.

## SYRINGOMYELIA

Roentgen Therapy of Syringomyelia. L. Delherm. *Strahlentherapie*, 1936, 56, 50.

The author reviewed the literature dealing with roentgen therapy of syringomyelia and found that of 160 cases reported, 124 (79 per cent) were considerably improved, while 32 (21 per cent) remained unchanged or grew worse later. In his own cases beneficial results were seen in about 60 per cent. Technique: 150 kv, 8-10 mm Al, 200 r per sitting up to 1,000 r per series, interval between series 3-4 weeks. Some patients receiving as much as from 15,000 to 20,000 r over a period of time without skin damage. The author treated 22 cases but seven of that number did not complete the treatment. Brief data on the remaining 15 are given: nine were improved, one case remained unchanged, and five grew worse in spite of the treatment. Roentgen therapy in syringomyelia is recommended.

ERNST A. POHLE, M.D., Ph.D.

## THROMBOPHLEBITIS

Roentgen Therapy of Thrombophlebitis. Fritz Eisler. *Strahlentherapie*, 1936, 56, 228-233.

In the author's opinion radiation therapy of thrombophlebitis has been a successful treatment method. In the early stages of the disease it may subside within one or two days after therapy; in later stages of the disease it is possible to shorten its course. In acute cases roentgen therapy should be carried out only if it is possible to apply irradiation without moving the patient. Technique: 140-160 kv, 3 mm Al or 0.3 mm Cu + 1 mm Al, depending on the depth of the affected vessels, 100 r over several areas to be repeated up to five times at intervals of from three to eight days.

ERNST A. POHLE, M.D., Ph.D.

dense shadow is produced which almost obliterates the superimposed skull markings if drainage is completely blocked. With incomplete drainage, the antrum may be partially filled with exudate with air overlying.

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Roentgenoscopy *versus* Roentgenography of the Chest A Wernli-Haessig Schweiz med Wehnschr, Feb 1, 1936, 66, 116-119

In an extensive study of pulmonary tuberculosis, the author compared the incidence of correct diagnosis by roentgenoscopy with roentgenography, and noted a 10 per cent error in the former method. This emphasizes the fact that roentgenography is indispensable in an early diagnosis of pulmonary tuberculosis. Approximately one half the errors were of the type in which no lesions were existent but one was "read in" by the roentgenoscopist. In the remaining cases, gross errors were committed. It is patent that even in the hands of the best trained roentgenoscopist, early lesions will be detected more often by roentgenography. The fact that numerous lesions were entirely overlooked by roentgenoscopy stresses the point that had not roentgenograms been obtained, these patients might have had possible rapid extension of the process without recognition thereof, until bilateral extension occurred and irreparable damage ensued. Roentgenoscopy is a valuable procedure when employed judiciously, and is indicated in every chest examination, as is well illustrated by an analogous analysis of cases examined by clinical and roentgenoscopic methods, respectively. Thus in 90 cases there was no clinical diagnosis made of uni- or bi lateral pulmonary tuberculosis, though it was noted roentgenoscopically. In every case of the entire series, the roentgenologic findings were far more extensive than clinical findings would suggest. The author goes into the minutiae of the method of a proper roentgenoscopic examination, which does not differ essentially from methods used in America. He advisedly emphasizes the importance of detecting retrocardiac lesions and pulmonary lesions situated in the neighborhood of the anterior and posterior costophrenic sulci, which can be easily overlooked in a single anteroposterior roentgenographic projection.

WILLIAM R. STECHER, M D

Use of the X rays in Pulmonary Tuberculosis from the Point of View of Prognosis Francis B. Trudeau Jour Am Med Assn, Feb 22, 1936, 106, 592-595

Much valuable information can be obtained from a careful study of roentgenograms of the chest in predicting the future trend of the disease and the patient's chance of ultimate recovery.

In 943 routine cases admitted within seven or eight years, only 3 per cent graded minimal on admission had died, while 15 per cent graded moderately advanced and 39 per cent graded far advanced had terminated fatally.

The soft, fluffy smoke shadow of the exudative type was compared with the more nodular, clean-cut and stringy shadow of the proliferative type, and it was found that only 39 per cent of the former had made satisfactory progress while 91 per cent of the latter had done well.

In another group of 925 routine admissions, cavities were visualized roentgenographically in 42 per cent.

At the end of five years, 35 per cent of these patients were dead, while of the remaining 533 patients only 20 per cent were dead. The percentage of deaths in patients with cavity was within 5 per cent of double that of those without cavity at admission. Under treatment in 36 per cent of 336 patients, the cavities remained approximately the same size. Of these, 34 per cent died within five years after leaving the sanatorium. In those in whom the cavities increased in size, 54 per cent were dead within a five year period. Of those in whom the cavities decreased or had disappeared completely only 11 per cent succumbed within a five-year period.

In 600 consecutive admissions, the patients were followed from three to five years after their discharge. In those whose x-ray films showed a steady healing of their disease only 9 per cent were dead, while in those whose roentgenograms showed a progression of the disease 37 per cent died.

The author found that progression of the disease as shown roentgenographically was of much graver significance than in cases in which it was indicated by physical signs.

The extent of lung involvement greatly influences the prognosis in pulmonary tuberculosis, the death rate being in direct proportion to the amount of disease. Progression in serial x-ray studies suggests a prognosis equally unfavorable with that indicated by the presence of fever. Patients with both fever and progression in serial roentgenograms have six times as unfavorable an outlook as those who are free from fever and whose roentgen examinations show constant improvement.

CHARLES G. SUTHERLAND, M B (Tor)

Indirect Fracture of the Rib in Pulmonary Tuberculosis Eric C. Richardson Jour Am Med Assn, May 2, 1936, 106, 1543, 1544

Twenty individuals showed fracture of one or more ribs, occurring as a result of muscular violence associated with coughing, from a series of 1,903 patients admitted over a five-year period. Ten additional cases were seen in the out-patient department.

Direct trauma was reasonably excluded in at least ten patients and there was no history in any case. Stimson mentioned the possibility of this accident in 1833. A review of the literature revealed a small number of reported cases.

CHARLES G. SUTHERLAND, M B (Tor)

Tuberculosis in Infancy and Childhood with Special Reference to its Prevention John W. S. Blacklock British Med Jour, Aug 15, 1936, No 3945, pp 324-328

The author investigated 434 cases with tuberculous lesions found in a series of 3,000 necropsies of children during the last twelve years at the Royal Hospital for Sick Children, Glasgow. Due to the uncomplicated character, and lack of immunity and allergy produced by previous tuberculous infection, it was relatively

## THE THYROID

Radiation Therapy in Basedow's Disease L. Brüll, B. van Pee, and P. Dumont *Strahlentherapie*, 1936, 56, 11

The authors subjected 65 patients with Basedow's disease to irradiation. Forty seven case reports are briefly quoted, covering observation periods of at least one and one half years. Technique: 200 kv, 1 mm Cu + 0.2 mm Al, 4 ma, 40 cm FSD, 300 r per sitting, two sittings per week, one field over each lobe, total dose per field 1,200 r. The larynx was carefully protected by 2 mm of lead. Irradiation often reduced the size of the gland and the symptoms disappeared.

The radiosensitivity of different patients varies considerably and, therefore, no standardized treatment can be prescribed. The response to radiation therapy is usually delayed and does not manifest itself before two or three series have been given during a period of several months. In cases treated with radium a severe anemia occasionally sets in which can, however, be cured. In a few instances a slight myxedema may follow radiation therapy, female patients during the menopause seem to have a tendency to develop this complication. Among the 65 cases there was only one death. The authors feel that there is great similarity between surgical removal and radiation therapy of Basedow's disease. Both methods are considered rather crude and the hope is expressed that future progress will lead to the development of a more physiological method of treatment.

ERNST A. POHLE, M.D., Ph.D.

## THE TONGUE

Malignant Tumors of the Base of the Tongue J. and L. Ducuing *Lyon Chir.*, November-December, 1935, 32, 641-683 (Reprinted by permission from *British Med. Jour.*, March 14, 1936, p. 44 of *Epitome of Current Medical Literature*.)

The authors discuss the pathology and treatment of malignant tumors of the base of the tongue of which there are three different types: the infiltrating type, which is seen in about 20 per cent of cases, the ulcerating type, which is the most common and the fungating form. The infiltrating type of growth is characterized by a thickening covered with apparently healthy mucosa which subsequently ulcerates. The ulcerating type of tumor has a round or irregular outline, and is covered with grayish sloughs.

The growth of epithelioma of the base of the tongue is slow and the early symptoms are slight. Examination reveals at this stage a small nodule, but later on pain and difficulty in swallowing are experienced, accompanied by extensive salivation and fetid breath. In some cases treatment is sought only after several months, during which the symptoms have been slight, but only in early cases is the prognosis at all favorable. As a rule, the tumor may be felt by means of digital

helpful in some cases when the growth is inaccessible to the finger. In all cases biopsy should be practiced to confirm a diagnosis of malignancy.

As regards methods of treatment, surgery is ineffective and dangerous for the primary lesion but is satisfactory for removal of the glands. Electrocoagulation is fairly satisfactory when the growth is not very extensive and is reasonably accessible. Radium needles become easily detached, and may cause lung complications. It is suggested that the radium bomb may be a useful method of treatment, but it has not been used long enough for results to be given. X-ray therapy is considered to be superior to radium as a method of treatment, it is suggested that irradiation should always be used for the glandular region, and also for the primary lesion. In cases in which the glands are only slightly affected, electrocoagulation may be useful for the primary lesion.

## TUBERCULOSIS, PULMONARY

Casustic Contributions Regarding the Appearance of Secondary Infiltration in the Course of Childhood Intrathoracic Tuberculosis F. Lichtenhahn *Schweizer med. Wchnschr.*, Feb. 1, 1936, 66, 109-114

Childhood tuberculosis involving the hilar lymph nodes is frequently accompanied by a more or less fugacious pneumonic infiltration in the adjacent pulmonary structure. This has been designated as peri focal secondary infiltration or as epituberculous infiltrate. The present concept is that this is a collateral exudative inflammation, in the contiguous environs, and an active tuberculous process which rarely and not necessarily results in caseous pneumonia. As a rule, this pneumonitis rather rapidly assumes a harmless course, disappearing entirely or leaving remnants of cicatricial tissue. The process occasionally occupies an entire lobe or even a lung, and roentgenographically simulates true lobar pneumonia. In certain instances, this peripheral pneumonitis and regional hilar lymphadenopathy, together with a negative von Pirquet reaction, have suggested the possibility that the appearance is resultant of pneumonitis about *Ascaris* embryos, in their temporary sojourn in the pulmonary parenchyma during their progress to the intestinal tract. This opinion, however, has had few adherents.

An important consideration of the above is the fact that contrary to prior opinion as to management and contagiousness of so-called childhood hilar lymphadenopathy of tuberculous origin and allergic manifestations in the lungs there is ample proof that in any phase of intrathoracic tuberculosis bacilli may be found in the sputum, which is usually scanty, feces and laryngeal mucus and particularly the gastric chyme. Guinea pig inoculation is positive in a high percentage of cases.

The article is excellently illustrated with roentgenograms depicting metamorphosis of the vagaries of childhood tuberculosis which lend weight to the author's deductions.

WILLIAM R. STRECHER, M.D.

the passage of a catheter. This procedure, however, is valuable in determination of function of the opposite kidney. An early diagnosis indicates nephrectomy, which is attendant with excellent results.

WILLIAM R. STECHER, M.D.

## TUMORS (DIAGNOSIS)

Multiple Myelomas with Tumor like Amyloidosis. A Clinical and Pathologic Study. A. H. Rosenblum and J. D. Kirshbaum. *Jour Am Med Assn* March 21 1936 106, 988-991.

The association of amyloidosis with multiple myelomas has been noted with increasing frequency in recent years. A review of the literature revealed 39 cases.

Amyloidosis may be classified as follows:

(1) Primary or osteopathic amyloidosis in which there is no apparent underlying suppurative or neoplastic condition. In this group there are two forms: (a) The diffuse or typical form as it occurs in the liver, spleen, kidneys, and so on—associated diffuse involvement of the bone marrow has been described by Gerber, (b) the localized or atypical form, in which a tumor-like amyloid deposit is present in the larynx and the base of the tongue, the muscles, trachea, and lung. These tumors may also be multiple and may be combined with the diffuse form.

(2) Secondary or symptomatic amyloidosis in which a known pre-existing cause is present, such as tuberculosis, neoplasms, or chronic suppurative processes. In this group there are two forms: (a) Diffuse involvement affecting typically the liver, kidneys, spleen, and adrenals, or atypically in sites that are usually spared, as the viscera, muscles, and bone marrow, (b) localized involvement which may occur within neoplasms or chronic inflammatory areas as in the form of tumor-like amyloid deposits, especially in the upper air passages.

Combinations of these types are frequently present.

In reporting a case the authors conclude from their own experience that in cases appearing as primary or so-called idiopathic amyloidosis, either local or diffuse, repeated biopsies are advisable to exclude the possibility of an underlying myeloma. In all cases of multiple myelomas the Congo red test should be performed in order to detect an eventually associated amyloidosis. In multiple myelomas, instead of the typical Bence-Jones protein, atypical proteins may be found in the urine, possessing the same diagnostic significance as the former.

CHARLES G. SUTHERLAND, M.B. (Tor.)

Multiple Symmetrical Lipomatosis. J. K. Miller. *Jour Am Med Assn* June 13 1936 106, 2059-2060.

Lipomas may occur anywhere within the body and have been found in the cranial cavity, the mediastinum, the uterus, and the marrow cavity of the bones. Because of their wide distribution they have been classified as subcutaneous, intermuscular, and visceral. The

majority are located under the skin and occur most frequently in the trunk, thighs, and arms. The face, scalp, sternal region, hands, and lower legs are infrequent sites. Three cases of multiple symmetrical lipomatosis observed in a mother, a son, and a daughter are presented. The tumors were noted in uncommon sites, namely the head and lower part of the legs on the mother and son. The distribution of the tumors in the son and daughter was similar. Possible endocrine disturbance may have been an etiologic factor in the mother.

A review of the literature shows the etiology of symmetrical lipomatosis to be obscure. A number of writers have linked the lipomas with neuropathies. Endocrine imbalance, particularly of the thyroid and pituitary, may be provocative agencies. A hereditary familial tendency has been noted. Adair reported the condition extending through three generations. He differentiated between multiple lipomas and "congenital diffuse lipomatosis." The latter is confined to one or two limbs and is usually associated with corresponding enlargement of muscles and bones of the same extremity. He considers multiple lipomas to be neuro-lipomas. They are not congenital but develop during adolescence and later life. Their frequent symmetrical distribution commonly confuses them with multiple neurofibromatosis. In suggesting a neurogenic origin for multiple lipomas, he admits a lack of histologic evidence.

CHARLES G. SUTHERLAND, M.B. (Tor.)

## TUMORS (THERAPY)

A Case of Plasma Cell Myeloma with One Single Focus. A. Rosselet and P. Decker. *Strahlentherapie*, 1936 56, 337-340.

The authors report a case of plasma cell myeloma which involved the fifth to the seventh cervical vertebrae. The diagnosis was verified by biopsy. The tumor was then incompletely removed. X-ray therapy was given post-operatively, after which the patient remained alive and well for four years without developing new foci. A recent recurrence responded well to radiation therapy.

ERNST A. POHLE, M.D., Ph.D.

The Problem of Acquired Radioresistance in Epithelial Tumors. Simone Laborde. *Strahlentherapie*, 1936 56, 466-477.

The author describes a number of cases illustrating the phenomenon of acquired radioresistance. A recurrence following previous irradiation, or failure of the tumor to disappear after the first series of treatments, presents difficult problems to the radiologist. It seems imperative to bring about healing with the first treatment or with two series closely following each other. There are several hypotheses advanced which attempt an explanation of the phenomenon, but none has histologic proof for its support.

ERNST A. POHLE, M.D., Ph.D.

easier to find the initial lesion to follow its course and to interpret the pathologic changes in children than in adults. In this series of 3 000 postmortem examinations the author found an incidence of 14.5 per cent of tuberculous infection. In the group of 434 cases of tuberculous lesions 89.2 per cent died as a result of tuberculosis. It was noted that the greatest mortality occurred during the first two years and then decreased with the increase in age of the child.

A benign childhood tuberculosis has been generally regarded as producing some immunity to such infection in later life. However in view of the fact that tuberculous infection during the first three years of life is so serious, it is believed extremely important to prevent such infection if possible. The effect of childhood lesions on later infection is not thoroughly understood. The South African Rand report states that tuberculin-positive negroes are more likely to develop a recognizable tuberculosis than tuberculin-negative reactors but the latter show a greater liability to develop a septicemic type. Stewart and Myers and Harrington observed that tuberculin-positive children more frequently develop fatal phthisis in later life than those who react negatively.

The author believes that the effect of allergy as a result of infection acquired later in childhood is entirely different from that acquired in infancy. This difference may be due to the fact that the younger child is more intimately and more frequently exposed to familial infection and also possibly to the higher natural immunity possessed by the older child. While there is a considerable difference of opinion in this regard the balance of evidence favors the view that minimal infection in later childhood probably affords some degree of protection against reinfection with small and infrequent doses of tubercle bacilli. The author is of the opinion that the indiscriminate and general use of BCG vaccine as recommended by Calmette for producing immunity in children is a procedure of questionable value and of possible danger. The use of killed cultures of tubercle bacilli is not as objectionable, and has been shown to produce immunity in animals. However, some consider the specific allergy produced in infants by these immunizing vaccines definitely unfavorable.

The main routes of infection by the tubercle bacillus are through the respiratory and alimentary systems. Infection occurred *via* the respiratory tract in 283 (65.2 per cent) of the 434 cases studied. The lesion noted in the lung was the rather typical small localized patch of caseous bronchopneumonia. This type of lesion is found only in the non-allergic individual. Parrot described this lesion 40 years before Ghon although it has been called "Ghon's tubercle." In the group of 283 cases such primary lesions were found in 255 cases. These lesions were usually subpleural and in the right upper lobe. Healing of these areas was noted to be much more frequent in the older age groups. The tracheo-bronchial glands were involved in all cases. As a result of these studies the author concludes that it is the glandular lesions which are

responsible for the dangers of these infections. He found dissemination of the infection more frequently in children under three years of age in whom glandular involvement was greater than in older children. Pulmonary tuberculosis was directly or indirectly the cause of death in 99.5 per cent of the children under three years and in 89.3 per cent in individuals over three years of age.

The organisms responsible for the lung lesions were isolated and typed and it was noted that the human bacillus was chiefly responsible while in only 3.6 per cent of cases was the bovine strain found.

In 149 or 34.3 per cent of the 434 tuberculous cases the portal of entry was *via* the gastro-intestinal tract. Death resulted from dissemination of the infection in 87.1 per cent in children under three years of age and in 29.8 per cent in children over three years of age. The organisms in this group were found to be in 82.2 per cent of cases of the bovine strain. Since it is relatively easier to prevent the alimentary form of tuberculosis than the respiratory form, every effort should be made to supervise the milk supply of children.

J. N. ANÉ M.D.

Hematogenous Disseminated (Miliary) Tuberculosis of the Lungs with Cure. C. Hegler and H. Holthusen. *Röntgenpraxis* March 1936 8, 161-169.

It is known that occasionally a miliary tuberculosis of the lungs has healed. Nine such cases are reported by the authors. In all these patients roentgenograms typical for miliary tuberculosis showed a more or less normal appearance after some time. The clinical diagnosis was proved in most cases. The course of the disease was acute in some, chronic in others. Some of the patients died later from tuberculosis.

H. W. HERKE M.D.

## TUBERCULOSIS, RENAL

The Early Diagnosis and Treatment of Renal Tuberculosis. Kurt Tzschirntsch. *München med. Wchnschr.* April 24 1936 83, 684-688.

Isolation of the tubercle bacillus by means of ureteral catheterization does not necessarily mean that the kidney is diseased for a normal kidney may filter out tubercle bacilli from an infected contralateral kidney or *via* pulmonary tuberculosis. A survey roentgenogram of the renal regions may reveal irregular calcification near the cortical outlines of the kidneys suggestive of renal tuberculosis. Retrograde pyelography is a most important procedure and early changes in calyceal outline are readily demonstrable. An accompanying irregularity of the ureteral outline and the bladder appearance are confirmatory evidence of tuberculous ureteritis and cystitis. It should be remembered from a clinical standpoint that any cystitis which does not respond to the usual therapeutic procedures should be considered as tuberculous until proven otherwise. In *travenous* urography it is to be employed only when retrograde pyelography cannot be undertaken *viz.* in cases of marked cystitis and ureteritis such as do not permit

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# RADIOLOGY

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NO. 6

## THE RADIATION BIOLOGY OF THE CUTANEOUS GLANDS

By J BORAK, Chief of the Roentgen Institute, Hospital of the Israelitischen Kultusgemeinde,  
*Vienna, Austria*

Translated from the German by E T LEDDY, M D, Mayo Clinic, Rochester, Minn

THE radiobiologic characteristics of the glands of the skin have a practical as well as a theoretical interest. Practically, they are important in the treatment of hyperhidrosis and acne. The theoretical importance they may have—a subject to which we shall confine ourselves—will be taken up in detail in this paper.

Our present knowledge of this subject is best presented by a repetition of the views of the following research workers in radiation biology.

Regaud and Lacassagne<sup>1</sup> summarize their views on this subject as follows: "If the irradiation has been intensive and of an intensity sufficient to cause death of the epidermis, or has even exceeded this dose, then the hair follicles and the dermal glands are destroyed." According to the views of these authors, the sebaceous and sweat glands are of equal radiosensitivity, and are as sensitive as the epidermis.

On the other hand, Holthusen<sup>2</sup> expressed the opinion: "The radiosensitivity of the appendages of the skin is somewhat greater than that of the epidermis." According to this view, the cutaneous glands have a greater radiosensitivity than that of the epidermis and, therefore, the radiosensi-



Fig 1 Normal skin (a) epidermis (b) sebaceous gland (c) hair (d) sweat gland

tivity of the sweat glands is about the same as that of the sebaceous glands.

In contrast to this view, Schinz and Slotopolsky,<sup>3</sup> on the basis of some theoretical considerations, expressed the opinion that the sebaceous glands (and the hair follicles) "are to be regarded as the most radiosensitive structures in the skin," and they admit that "very little is positively known about the radiation biologic characteristics of the sebaceous glands."

<sup>1</sup> Regaud and Lacassagne. *Lazarus Handbuch d. ges. Strahlenheilk.*, 1927, 2.

<sup>2</sup> Holthusen. *Lazarus Handbuch*, 1928.

<sup>3</sup> Schinz and Slotopolsky. *Erg. med. Strahlenforsch.*, 1928.



## THE UTERUS

Indications and Treatment Methods in Radiation Therapy of Uterine Fibroid G Gambarow Strahlentherapie, 1936, 56, 75

The author briefly discusses the indications and various treatment methods practised in leading clinics in radiation therapy of uterine fibroids. After an analysis of his experience in over a thousand cases he concludes that in uterine bleeding due to fibroid or metropathia roentgen therapy should not be used in patients under 40 years because of the severe climacteric symptoms. In patients under 40 years he chooses either operation or radium therapy. Diagnostic curettage must be done before using irradiation. In very large uterine fibroids operation is considered by the author as the method of choice. He also feels that radium therapy is in some cases preferable to roentgen therapy because the bleeding stops much quicker and the menopausal symptoms are not so severe.

ERNST A. POHLÉ M.D., Ph.D.

Early Diagnosis of Carcinoma of the Cervix by the Colposcope. M. Kranzfeld Schweiz med Wchnschr, Feb 29, 1936, 66, 223-225

By means of this instrument devised by Hinselmann, one can view the cervix enlarged ten diameters and this affords an excellent method of detecting early carcinomatous changes. The author reports two cases in which the diagnosis was established only by this method. Furthermore, the colposcope enables one to obtain proper biopsy, by directing to the proper site, and in instances the entire incipient carcinomatous process was included in the biopsy specimen. After reviewing over 1,500 colposcopies, the author disagrees with Hinselmann, in regard to certain so-called precancerous lesions, viz., leukoplakia, and iodine negative test regions. In reviewing these cases over a three-year period not one case presented evidence of malignant change. The colposcope is an exceedingly valuable addition to the armamentarium of the physician, but should be employed only by skillfully trained specialists.

WILLIAM R. STECHER, M.D.

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Fig 1 Normal skin (a) epidermis, (b) sebaceous gland (c) hair, (d) sweat gland

tivity of the sweat glands is about the same as that of the sebaceous glands.

In contrast to this view, Schinz and Slotopolsky,<sup>3</sup> on the basis of some theoretical considerations, expressed the opinion that the sebaceous glands (and the hair follicles) "are to be regarded as the most radiosensitive structures in the skin," and they admit that "very little is positively known about the radiation biologic characteristics of the sebaceous glands."

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<sup>3</sup> Schinz and Slotopolsky. *Erg. med. Strahlenforsch.* 1928.

It is apparent from the foregoing that the views in regard to the sensitivity of the different structures of the skin are not in harmony any more than are the views concerning the sensitivity of the cutaneous glands, as they are contradictory in some of the essential points

There are many reasons for this state of affairs. The number of anatomical studies which have appeared during the forty years of radiology which deal with the changes produced in the glands of the skin by radiation are very few in number. Thus may well be due to the fact that the changes in the cutaneous glands are of less interest and importance than, for example, those in the vessels, because changes in the latter are of far greater clinical importance than are the changes that may ensue in either the sebaceous or the sweat glands. And, insofar as the anatomical studies on the cutaneous glands as affected by irradiation, there is no definite ground of comparison between them, because either the experimental animals used were such that direct comparisons could not be made, or else only one of the various glands in the skin was the subject of the investigation. In the few reports available on the characteristics of either the sweat glands or the sebaceous glands, we are usually given some individual observations and not, which is so necessary, the results of a serial investigation carried out in an extensive way. In these reports either the details of dosage are not given at all or else they are stated ambiguously.

In the same way, the time intervals or the concentration at which the doses were given are almost always ignored. Finally, in the determination of the radiosensitivity of the various tissue components, heterogeneous effects are often considered. It should be clear that, for example, the temporary loss of hair, the swelling of the vascular endothelium, and the suppression of the secretion of sweat are effects which are absolutely incommensurable, and from a comparison of such effects no conclusions about the radiosensitivity of the tissue in

fact, the only way to determine the radiosensitivity of a tissue is to determine its lethal dose. Aside from the difficulties of determining whatever degree of injury may be present in the tissue as a result of radiation, there is no criterion so absolute in the definition of the sensitivity of a tissue, particularly with regard to its destructive character, as the *complete disappearance of the tissue*. According to this point of view, a dose can be called lethal only when its effect is manifested by a complete anatomical disappearance of the tissue. This leads us to the point that problems of the biology of radiation cannot be solved by clinical observation alone, but that in their solution the histologic findings are of fundamental importance.

Our own extensive investigations, carried out during recent years, have led us to results which we may summarize as follows:

A quantity of radiation which produces an ulcer or, in other words, a necrosis, of connective tissue destroys the epithelial elements of the skin at the same time, that is to say, the sweat glands and the sebaceous glands, together with the epidermis and the hair follicles (Fig 2)

A quantity of radiation which results in an epidermolysis, that is, a destruction of the epidermis without necrosis of the connective tissues, destroys at the same time the sebaceous glands and the hair follicles, but spares the sweat glands, even years after. The function of the sweat glands, however, ceases (Fig 3)

A quantity of radiation which produces a permanent epilation but no other injury, destroys the sebaceous glands, but leaves the epidermis and the sweat glands intact. The function of the sweat glands stops (Fig 4)

A quantity of radiation which produces temporary or partial epilation may also destroy the sebaceous glands, while the epidermis and the sweat glands remain intact though the latter may lose their function (Fig 5)

With a single exposure—

The lethal dose of the sweat glands is approximately

2,500 r



Fig 2 Radiation necrosis All epithelial elements are destroyed

The lethal dose of the epidermis is approximately	2,000 r
The lethal dose of the hair follicles is approximately	1 000 r
The lethal dose of the sebaceous glands is approximately	1 200 r

We can state from these facts that there is a definite difference in the radiosensitivity between the various epithelial components of the skin and that this difference is especially well marked between the two varieties of cutaneous glands. We have seen that the sebaceous glands have a different radiosensitivity from the sweat glands. The sebaceous glands are by far the most radiosensitive, the sweat glands the most radiosensitive epithelial elements of the skin. The sebaceous glands are far more radiosensitive than the hair follicles, the sweat glands are less radiosensitive than the epidermis.

This very definite difference in radiosensitivity between the sebaceous and sweat glands is attested to not only by the height of the lethal dose but also in the duration of the *latent period* before the destruction of the radiated tissues. After administration of the necessary lethal dose the latent period in the case of the sebaceous glands is only three or four weeks, whereas in the case of the sweat glands it is three or four months at least.

The mechanism of cellular destruction is of special interest. If a dose is given that



Fig 3 Epidermolysis The sebaceous glands and the hair are destroyed the sweat glands remain

causes disappearance of only the sebaceous glands while the sweat glands persist, one may determine that the sebaceous glands are destroyed directly, insofar as their matrix, the basal cells, sustain an injury as a result of which they themselves are destroyed in part, and in part their derivatives. The *blood vessels* sustain only temporary injury, at least insofar as the endothelium is concerned. The lumen remains open so that the blood supply of the tissues is not markedly impaired.

The changes taking place at the same time in the sweat glands aside from the early changes, which run a rapid course, consist for the most part in a decrease in the size of the individual cells and the glandular acini, which changes are due to interruption of the activity of the glands.

The necrotizing process leading to complete disappearance of the cells occurs when severe damage to the blood vessels occurs at the same time, which may take the form of an endarteritis obliterans or to thrombosis and obliteration of the vascular lumen. As we watch this process we see that the sweat glands do not sustain a primary and direct injury from radiation, but that their dam-

age results from a severe interference with their nutrition, from which there results a diffuse necrosis and disappearance of all



Fig 4 Permanent epilation  
The hair and the epidermis are  
destroyed the sweat glands are not



Fig 5 Sebaceous glands are destroyed The  
epidermis a large part of the hair and in the  
deeper layers the sweat glands remain

landmarks. It can be demonstrated that the complete disappearance of the sweat glands is sharply limited to the zone of necrosis and that at the edge of the ulceration glandular rests in more or less good condition can be found.

From these facts it seems justifiable to state that the sebaceous glands sustain an *elective* injury, whereas the sweat glands sustain a *nutritive* injury. From here we can go a step further and say that only those tissues which are destroyed in an elective way, that is to say, primarily and directly, can be regarded as *radiosensitive*, on the other hand, those which are affected secondarily as the result of a severe injury to the vessels are to be regarded as *non-radiosensitive* (resistant). If the terms are applied in this anatomical—and, therefore, definite—sense, much of the confusion in the literature can be avoided.

If we investigate the causes of this polar relationship of the sweat and sebaceous glands toward radium and roentgen rays, we shall find an answer to the problem, insofar as these structures lie so close to-

gether that they must receive exactly the same dose of radiation. Therefore, the differences in their reaction must be due not to a radiophysical cause but to a radiobiologic, in that there can be no great difference in the dose of radiation which is absorbed. In fact, there is a great difference in the anatomical structure of these glands as well as in their physiologic functions. The sebaceous glands are holocrine, whereas, the sweat glands are, on the contrary, merocrine. As is well known, the holocrine glands are destroyed in the formation of their secretion, while the merocrine glands form their secretion without entering into its makeup. These two methods of secretion cause differences in the structure of the two classes of glands. The sebaceous glands are made up of several epithelial layers, whereas the sweat glands have only a single layer of epithelium. In the case of the sebaceous glands there takes place a structural transformation of the various kinds of cells, in which process the deeper cells come to be transferred to the surface as a result of which a secretion is formed. The sweat glands, on the other hand, preserve their structure during the process of secretion, so that only their size varies with the various phases of secretion, in that they enlarge during the period of the formation of the secretion and become smaller when it has been poured out.<sup>4</sup>

<sup>4</sup> See the text books on histology by J. Schaffer, Ph. Stoehr, and others.

We are, therefore, concerned with the differences between a temporary and a permanent tissue, on which difference Schinz<sup>5</sup> several years ago was inclined to base the well-known differences in the radiosensitivity of various tissues. The appendages of the skin which show such great differences on close anatomical analysis, and yet which have been regarded as showing so little variation in their spacial distribution, illustrate very emphatically the importance of anatomical activity in determining the radiosensitivity of tissue. The dependence of the radiosensitivity of a tissue on whether it is a temporary or a permanent structure is illustrated very clearly by our studies. For the relationships between the holocrine and the merocrine glands are merely a special manifestation of the relationships between temporary and permanent tissues. The sebaceous and the sweat glands are good examples of holocrine and merocrine glands as well as examples of temporary and permanent tissues. They may also be regarded—in the sense of the definition given above—as good examples of radiosensitive and radioresistant tissues.

The following tissues behave toward radiation in the way the sebaceous glands do: the lymphopoietic tissues, the hematopoietic tissues, the ovarian follicles, the spermatogenic epithelium of the testis, the hair follicles, the epidermis, the basal epithelium of the mucous membranes.

The following tissues react toward radiation in about the same way as the sweat glands: connective tissue, muscle, the

nerves, the brain, bones, glandular epithelium, and blood vessels.

Tissues which belong in the same group as the *sebaceous glands* are characterized in a special way both anatomically and from the standpoint of radiation biology. From an anatomical point of view, they are temporary tissues, that is to say, they possess the power of physiologically regenerating the cells which have died. For this reason they are made up of several layers of cells, from which one forms the matrix, the others differentiate from it. At the end of this process of differentiation there is a variety of cells which are lifeless or incapable of living. From a radiobiologic point of view they are sensitive, that is to say, they can be killed off to the point of complete disappearance, without producing any irreparable damage to the blood vessels.

Tissues in the same group as the *sweat glands* also have certain characteristics. Anatomically they are made up of only one kind of cells, which have a single function and in case they are accidentally killed off they are not replaced by the same kind of cells. These tissues are radioresistant, that is to say, they may be depressed functionally directly and primarily by radiation and changed in a degenerative sense. Their complete disappearance results secondarily in a severe vascular damage, with consequent interference with the blood supply.

Thus we see that a study of the radiobiology of the dermal glands may furnish us with information of greatest importance from the standpoint of the general biology of radiation effects.

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<sup>5</sup> Klin. Wchnschr., 1925

age results from a severe interference with their nutrition, from which there results a diffuse necrosis and disappearance of all



Fig 4 Permanent epilation  
The hair and the epidermis are  
destroyed the sweat glands are not



Fig 5 Sebaceous glands are destroyed The  
epidermis a large part of the hair and in the  
deeper layers the sweat glands remain

landmarks. It can be demonstrated that the complete disappearance of the sweat glands is sharply limited to the zone of necrosis and that at the edge of the ulceration glandular rests in more or less good condition can be found.

From these facts it seems justifiable to state that the sebaceous glands sustain an *elective* injury, whereas the sweat glands sustain a *nutritive* injury. From here we can go a step further and say that only those tissues which are destroyed in an elective way, that is to say, primarily and directly, can be regarded as radiosensitive, on the other hand, those which are affected secondarily as the result of a severe injury to the vessels are to be regarded as non-radiosensitive (resistant). If the terms are applied in this anatomical—and, therefore, definite—sense, much of the confusion in the literature can be avoided.

If we investigate the causes of this polar relationship of the sweat and sebaceous glands toward radium and roentgen rays, we shall find an answer to the problem, insofar as these structures lie so close to-

gether that they must receive exactly the same dose of radiation. Therefore, the differences in their reaction must be due not to a radiophysical cause but to a radiobiologic, in that there can be no great difference in the dose of radiation which is absorbed. In fact, there is a great difference in the anatomical structure of these glands as well as in their physiologic functions. The sebaceous glands are holocrine, whereas, the sweat glands are, on the contrary, merocrine. As is well known, the holocrine glands are destroyed in the formation of their secretion, while the merocrine glands form their secretion without entering into its makeup. These two methods of secretion cause differences in the structure of the two classes of glands. The sebaceous glands are made up of several epithelial layers, whereas the sweat glands have only a single layer of epithelium. In the case of the sebaceous glands there takes place a structural transformation of the various kinds of cells, in which process the deeper cells come to be transferred to the surface as a result of which a secretion is formed. The sweat glands, on the other hand, preserve their structure during the process of secretion, so that only their size varies with the various phases of secretion, in that they enlarge during the period of the formation of the secretion and become smaller when it has been poured out.<sup>4</sup>

<sup>4</sup> See the text books on histology by J. Schaffer, Ph. Stoehr, and others.

closely and baked to the hardness of porcelain. Motion of the grid and filament relative to each other and to the head is se-

transformers which supply the tube filament. A potentiometer with a paraffined string to the control room controls the bias

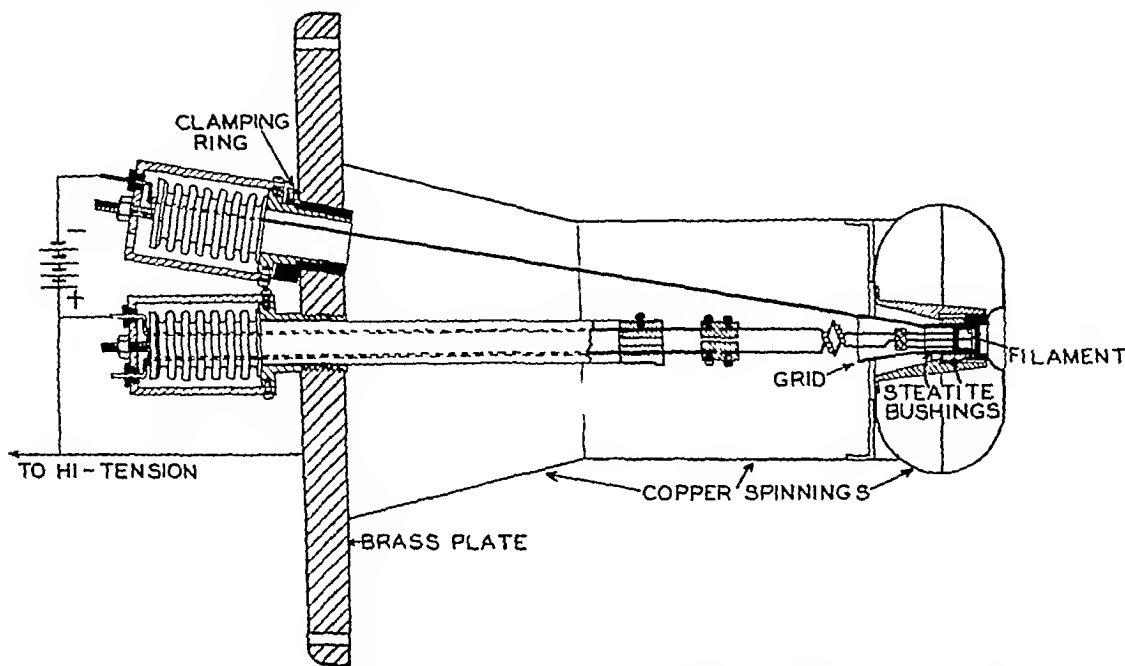


Fig 2 Schematic diagram of electrically biased cathode head

cured by means of sylphon bellows adjusted by a single screw in each case. The filament may be replaced without removing the head by unscrewing the bellows assembly which removes the filament assembly without disturbing other parts. Due to the fact that the filament is well insulated thermally from the surrounding metal, heat dissipation is poor and due to expansion proper spacing cannot be maintained unless an insulation ring of about 0.5 mm thickness is interposed between the face of the grid and the filament. Then by pushing the filament barrel solidly against the grid a constant clearance can be maintained. The grid may be removed as a unit by loosening the clamp screws and slipping the whole straight out. A vacuum seal is maintained with a cement similar to de Khotinsky.

The grid is charged negatively with respect to the filament by means of small-sized "B" batteries or by a rectifier using 280 type tubes and suitable condensers, the rectifier being furnished power by the insulating



Fig 3 Cloud chamber photograph of 306 kv electron path

voltage, another string and rheostat control the filament, the whole being mounted in a 15-inch spun aluminum sphere attached to the high voltage source.



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## ABSTRACT

effect of bias on the current wave-form. Absorption curves in lead show an increase in "equivalent" voltage, i e., average hardness of radiation. The r output is increased approximately 35 per cent, and focusing is made easier.

wound plane spiral of 8 5 mil tungsten wire about 5 mm in diameter. Insulation between the head and the grid and between the grid and filament is achieved by means of two steatite<sup>2</sup> bushings machined to fit

In order to test the effect of cathode bias on this type of tube and voltage waveform, the cathode head shown in Figure 2 was built. A brass plate which serves to close the end of the x-ray tube supports the copper spinnings which in turn support the grid-filament assemblies. The copper nose spinning is of the same dimensions as in the original head and the filament depression, or cup, has approximately the same form. The grid consists of thin copper tubing flared at the end to facilitate replacing the filament and spun over at the other end to a hole  $\frac{5}{16}$  inch in diameter, slightly larger than the spiral tungsten filament. The standard filament consists of a tightly

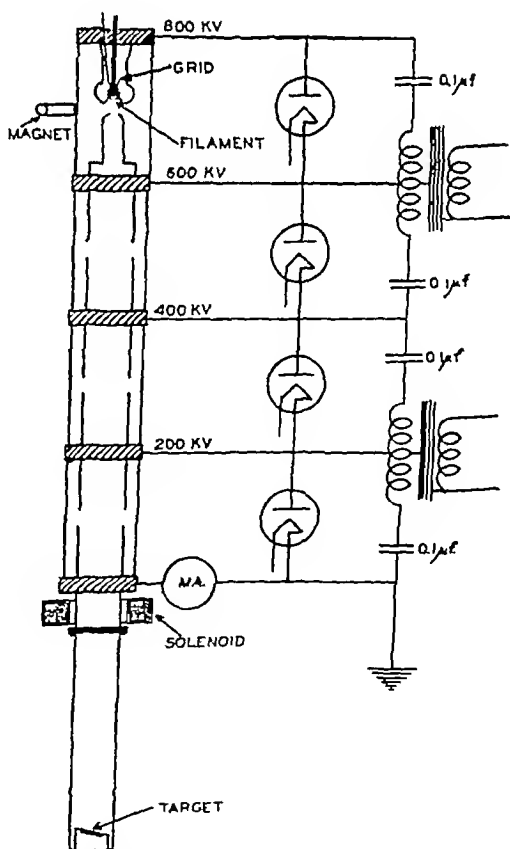


Fig 1 Schematic diagram of General Electric (KXC-2) kvp x ray installation

<sup>1</sup> By the General Electric X ray Corporation

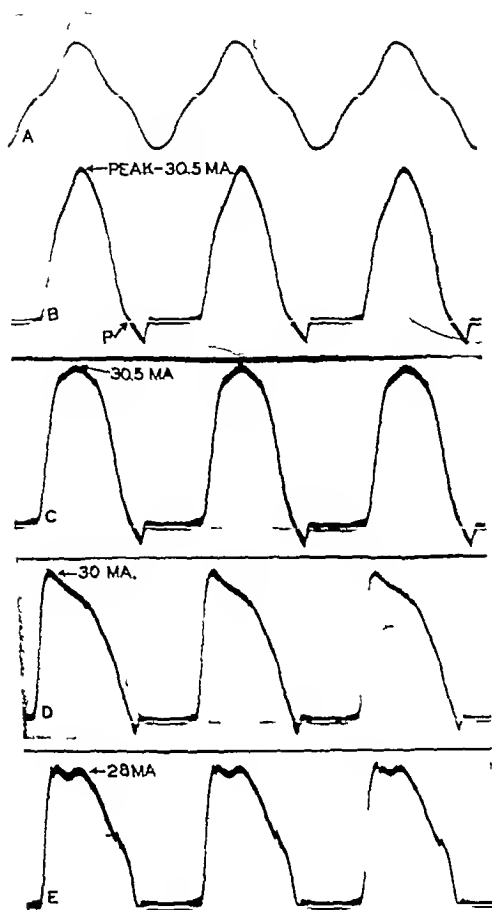


Fig 5 Oscillograms of tube current using original cathode head

- A, 60-cycle timing wave
- B Tube current 9.0 ma (RMS) 6 mm 'mechanical' bias
- C Tube current 10 ma (RMS), 4 mm 'mechanical' bias
- D Tube current 10 ma (RMS) 2 mm 'mechanical' bias
- E, Tube current 10 ma (RMS) 0 mm 'mechanical' bias

Note D and E show small high frequency peaks due to improper focusing

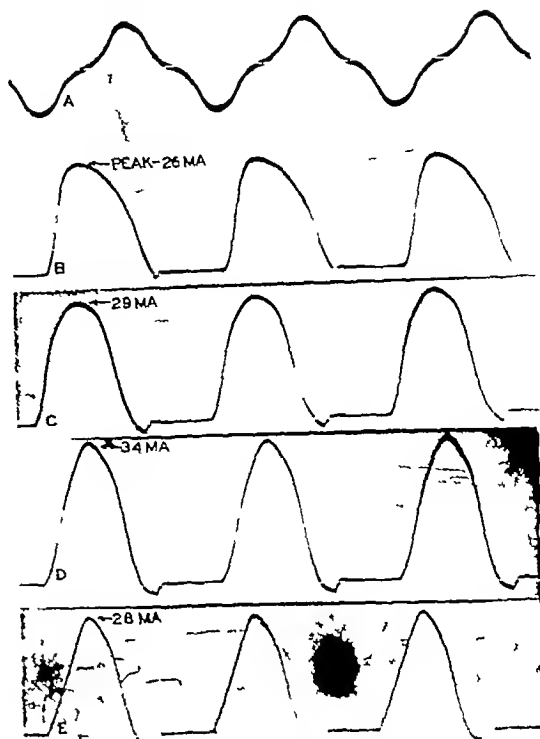


Fig 6 Oscillograms of tube current using electrically biased cathode head

- A 60-cycle timing wave
- B, Tube current 10 ma (RMS) no electrical bias
- C Tube current 10 ma (RMS) 100 volts bias
- D Tube current 10 ma (RMS), 200 volts bias
- E Tube current 8 ma (RMS) 300 volts bias

responds to an electron energy of 806 kv. Details of this determination will be published elsewhere.

Absorption curves were taken in both lead and water. The water curve, taken with an added filter of 4.75 mm of lead and 225 volts grid bias (therapy conditions yielding 50 "equivalent" r per minute at 70 cm T S D), shows a half-value layer of 7.1 cm of water corresponding to 500 kv "equivalent voltage" (2) according to the curve published by Lauritsen (2, 3, and 4). The lead curves are shown in Figure 4, the upper curve, using 225 volts grid bias, shows at a filter of 4.75 mm of lead an absorption

were determined with the rotary voltmeter(1). The peak voltage has also been checked by an independent means, *i.e.*, by a determination of the short wave length limit by introducing into the beam from the 800 kv tube an automatic Wilson cloud-chamber designed by one of us (D H L). Figure 3 shows a photograph taken with this apparatus of the path of an electron having a radius of curvature of 11.0 cm in a field of 386 gauss. This cor-

\* Since the method of measuring roentgens at these voltages has not yet been agreed upon, all r measurements in this paper were determined with a Victoreen condenser-type dosimeter and are referred to as "equivalent r" in order that comparisons may be made by other laboratories having the same equipment.

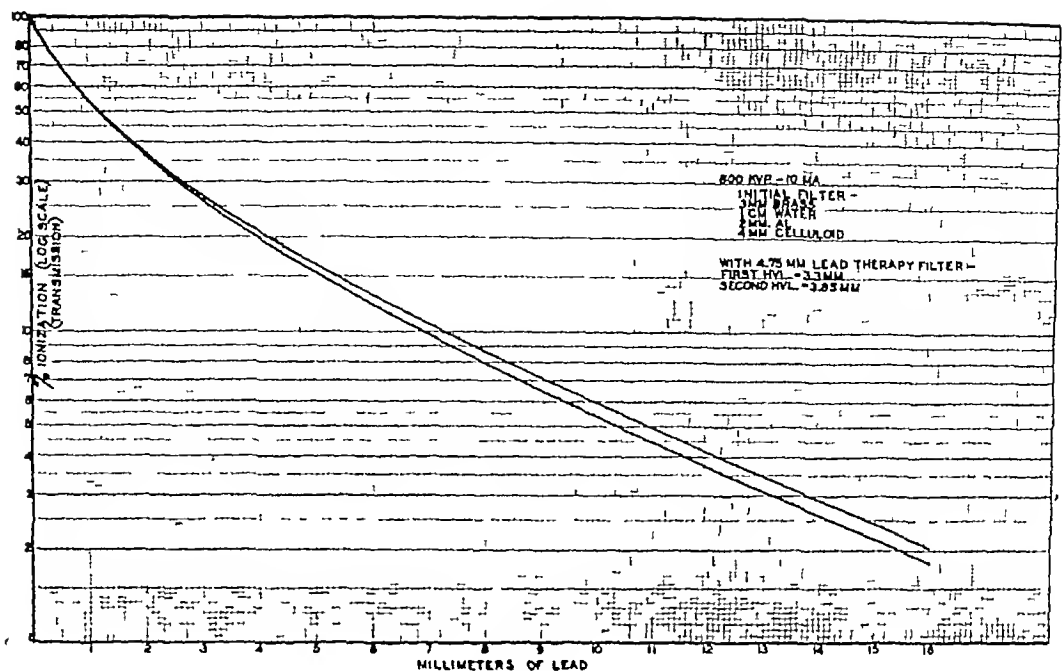


Fig 4 Lead absorption curves, upper curve taken with 225 volts grid bias lower curve with 5 mm mechanical bias

A systematic investigation of the effect of various spacing arrangements between filament and grid and between the grid and the face of the head using various bias voltages was made using the *r* output as an indicator of the most desirable position. It was found that with the grid about 1.0 cm from the face of the head and with a space of about 0.5 mm between the grid and filament, the maximum *r* output is secured with a tube current of 10 ma, 225 volts on the grid, and 4.75 mm lead filter in addition to the inherent filter in the tube. With the above factors the efficiency of output is increased approximately 35 per cent, *i.e.*, one is able with the above conditions to secure the same *r* output with 7.4 ma tube current as was formerly obtained with 10 ma. Increasing the grid voltage beyond 225 volts with the above settings makes it impossible to maintain the tube current at the usual 10 ma. In an attempt to further increase the efficiency of output by utilizing still higher bias voltages, a filament of approximately twice the emitting area of the standard filament was introduced. Al-

though the larger filament was operated at temperatures exceeding its rating, the gain in *r* output was of the order of only a few per cent even when the grid and filament were placed flush with the face of the head and a bias of 600 volts applied. This would seem to indicate that the smaller standard filament is adequate for the present design of head. In the original head the filament was situated in a cup about 1.0 cm deep and the tube was operated for therapy with the filament withdrawn into the well at the base of the cup a distance of from 5 to 5.5 mm. This condition produces a certain degree of bias as shown by the oscillograms to be discussed later and referred to as "mechanical" bias.

It is found that the electrically charged grid arrangement gives considerably better focussing of the electron beam in its  $12\frac{1}{2}$ -foot passage through the tube. The current loss to the intermediate electrodes, schematically illustrated in Figure 1, is reduced from 150 micro-amperes to about 10 microamperes.

Voltage wave-forms and peak voltages

oscillograph was installed on a platform mounted on the 800 kv lead to the tube. The tube current was entirely carried by the oscillograph element. Figures 5 and 6 show, respectively, the wave-forms obtained for various bias with the original head, using mechanical bias, and the present head with electrical bias. Under each figure are indicated the values of tube current and bias used. The top curve in each figure is a 60-cycle timing wave obtained from an auxiliary transformer winding on the 800 kv insulating transformer. This source accounts for the presence of the prominent third harmonic. All of the oscillograms show the presence of a negative tube current due to space charge around the filament. The magnitude of this negative current is a direct function of the amount of bias present, as is clearly seen from the curves. In a separate series of experiments with the oscillograph at the grounded end of tube these inverse currents were entirely absent.

In order to carefully analyze the differences shown in these various curves all the oscillograms were put through a harmonic analyzer (Mader, of Munich), which could measure all components through the ninth. A careful study of the amplitudes and phase angles of the various components of these waves did not yield any definite physical conclusions, although one sees a definite trend, in both cases of mechanical and electrical bias, for the percentage of fundamental and second harmonic frequency to increase with increasing bias, while the third and fourth components either remain percentage roughly constant or decrease with increasing bias.

An important point to notice in Figures 5 and 6 is the radically different shapes to the inverse currents due to space charge in the case of mechanical and electrical bias. In the former case these are sharp peaks in all cases, whereas in the electrical bias these sharp peaks are smoothed over and the removal of the space charge occurs over a percentage larger fraction of the time.

Since the voltage wave-form is known(1) to have positive values over 250 electrical

degrees and also to be quite constant over any values of loads used in these experiments, one can measure back on all curves from the point at which the current reverses (Point P in Figure 5-A) a distance corresponding to this number of electrical degrees. The number of electrical degrees between the points so determined and the point of initial current on each oscillogram is plotted against the respective bias in Figure 8. Since one does not know exactly the point of zero mechanical bias, the curves are not drawn through these points. There is seen, however, a marked tendency for the initial portion of each current wave to lag further and further behind the initial portion of the voltage wave as the bias is increased. This causes the peak of the current and voltage waves to more nearly coincide and since the efficiency of x-ray production varies as roughly the 2.5 power of the voltage, a very slight peaking of the current wave-form with its maximum occurring near the peak of the voltage wave, will, for the same tube current as measured by an integrating type of ammeter, account for a relatively large increase in r output.

### CONCLUSIONS

It is concluded that a cathode bias is an easily obtained and very desirable addition to a supervoltage tube of this type, since the output is definitely improved and the resulting radiation definitely hardened.

### ACKNOWLEDGMENTS

We wish to express our appreciation to Dr. N. A. Johanson, Chief of Staff of the Swedish Hospital, and to Dr. John E. Wirth, Director of the Tumor Institute, for the use of the facilities extended. We are indebted to Mr. Harold Trueblood for the use of Figure 3, also to Mr. Z. J. Atlee, of the Vacuum Tube Department, General Electric X-ray Corporation, for the fabrication of the special filaments, and Mr. David Lind for his assistance during the experiments.

coefficient ( $\mu^{cm-1} = 2.1$ ) which corresponds to 450 kv "equivalent voltage" as determined from the data of Reed(5) and Jones(6)

(formerly used for therapy) an absorption coefficient ( $\mu^{cm-1} = 2.5$ ) which corresponds to 400 kv "equivalent voltage"

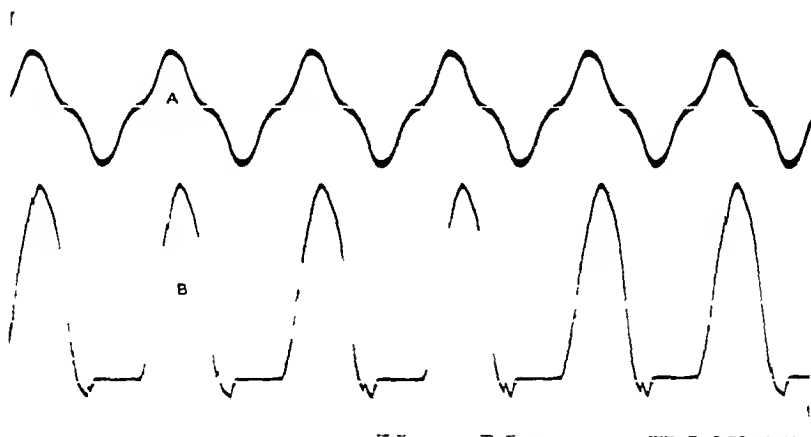


Fig 7 Oscillogram of tube current using electrically biased cathode head showing high frequency currents superimposed on tube current by improper focusing of electron beam

A 60-cycle timing wave

B Tube current 10 ma (RMS) 200 volts bias

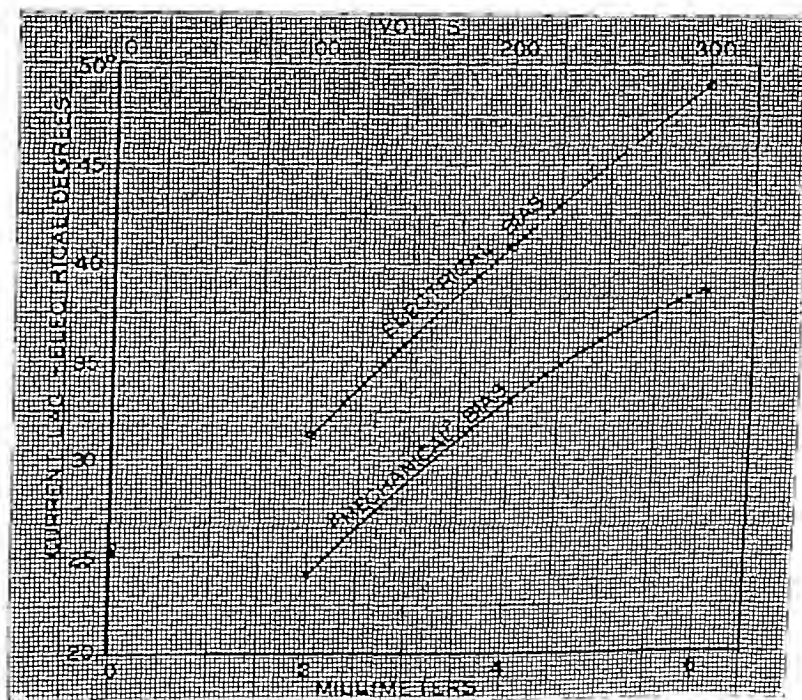


Fig 8 Upper abscissa potential applied to grid of cathode head lower abscissa distance filament withdrawn below base of filament cup

The lower curve obtained while using the original head with a mechanical bias of 5 mm, shows at a filter of 3.1 mm of lead

In order to study the effect on current wave-form of various electrical and mechanical bias, a PM10 General Electric

# SIMULTANEOUS INFRA-RED ROENTGEN PHOTOGRAPHY

A METHOD OF OBTAINING A PHOTOGRAPH IN TOTAL DARKNESS, AND  
A RADIOGRAPH, SIMULTANEOUSLY, ON THE SAME INFRA-RED PLATE

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INFRA-RED photographs in so-called total darkness have been obtained with various filters, such as the Wratten No 87 infra-red filter. Infra-red photographs in so-called total darkness, of various sources of heat have also been obtained. It has also been shown that by directing a source of heat toward an object, excellent infra-red photographs can be made. Whenever a source of heat is used in this way the exposure time is considerably prolonged. For example, in the latter instance, with the aid of two hot flatirons, the infra-red photograph was obtained after an exposure time of one hour. In the experiments under consideration, however, the exposure time for the infra-red photographs which are taken in *total darkness* range from 1 to 10 seconds.

*Material and Methods*—The apparatus employed in these experiments is shown in

tight box with the emulsion side of the plate directed upward. A *Cecropia* moth is placed upon the photographic plate in con-

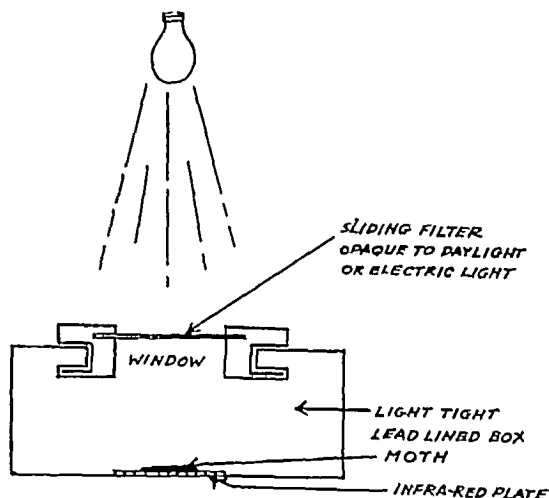


Fig 1 Diagram of photographic apparatus



Fig 2 Infra red photograph of a *Cecropia* moth which was first placed in a light-tight box and then exposed to the light from a 500 watt tungsten bulb for 8 seconds. Eastman infra red plate Type 1R. Contact print.

Figure 1 An Eastman type 1R infra-red plate is placed inside of a lead-lined light-tight box with the emulsion side of the plate directed upward. The sliding filter, opaque to the visible spectrum, is closed

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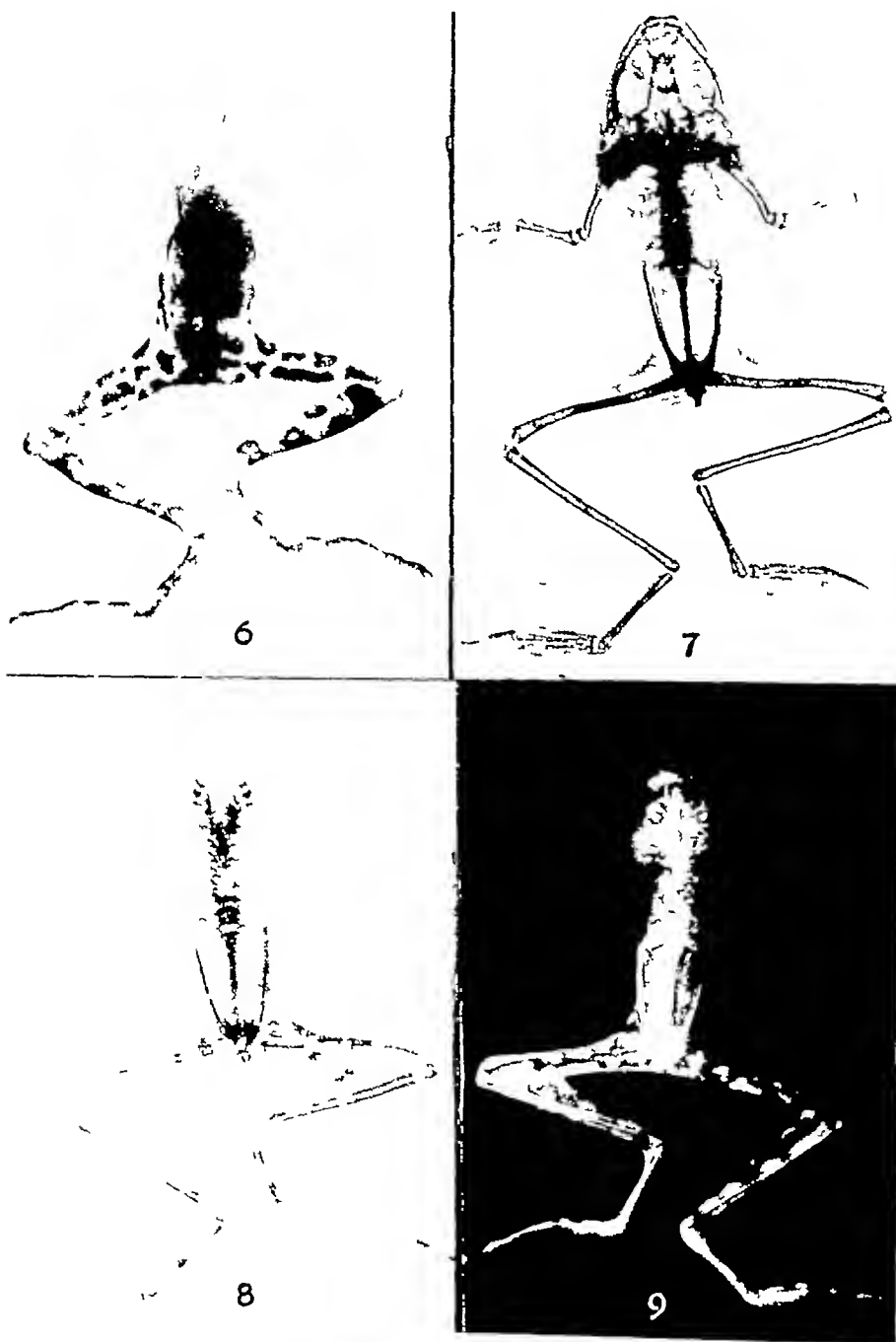


Fig 6 (upper left) Infra red photograph of a frog The same photographic technic was used Exposure time 10 seconds Contact print

Fig 7 (upper right) Roentgenogram of a frog taken under the same conditions as Figure 6 Contact print

Fig 8 (lower left) Infra red roentgen photograph of a frog taken under the same conditions as Figures 6 and 7 but exposed to the roentgen ray and to light simultaneously for 10 seconds Contact print

Fig 9 (lower right) The negative used in Figure 8 was rephotographed and then a print made



over the window in the box, thus placing the infra-red plate and the moth lying on the plate in total darkness. This so-called



Fig 3 Roentgenogram taken under same conditions as Figure 2 but exposed to the roentgen ray for 9 seconds. Eastman infra red plate Type 1R. Contact print.

filter, which closes over the window in the box, was made from a plate holder slide marked with four dots, which is safe to use in the plate holder with the ordinary photographic emulsions, but which, when used with the infra-red plate and exposed to light, will cause fogging of the plate. Daylight or the light from an incandescent tungsten bulb is then directed through the filter in the window of the box for eight seconds. The loading of the box and development of the plate are done in total darkness. Infra-red materials and methods are discussed by the author in detail in three previous publications (Massopust 1, 2, and 3).

*Observations* — Upon development the re-



Fig 4 (upper) Infra red roentgen photograph taken under the same conditions as Figures 2 and 3 but exposed to the roentgen ray and to light simultaneously for 8 seconds. Eastman infra red plate Type 1R. Contact print.

Fig 5 (lower) The negative used in Figure 4 was rephotographed and then a print made.

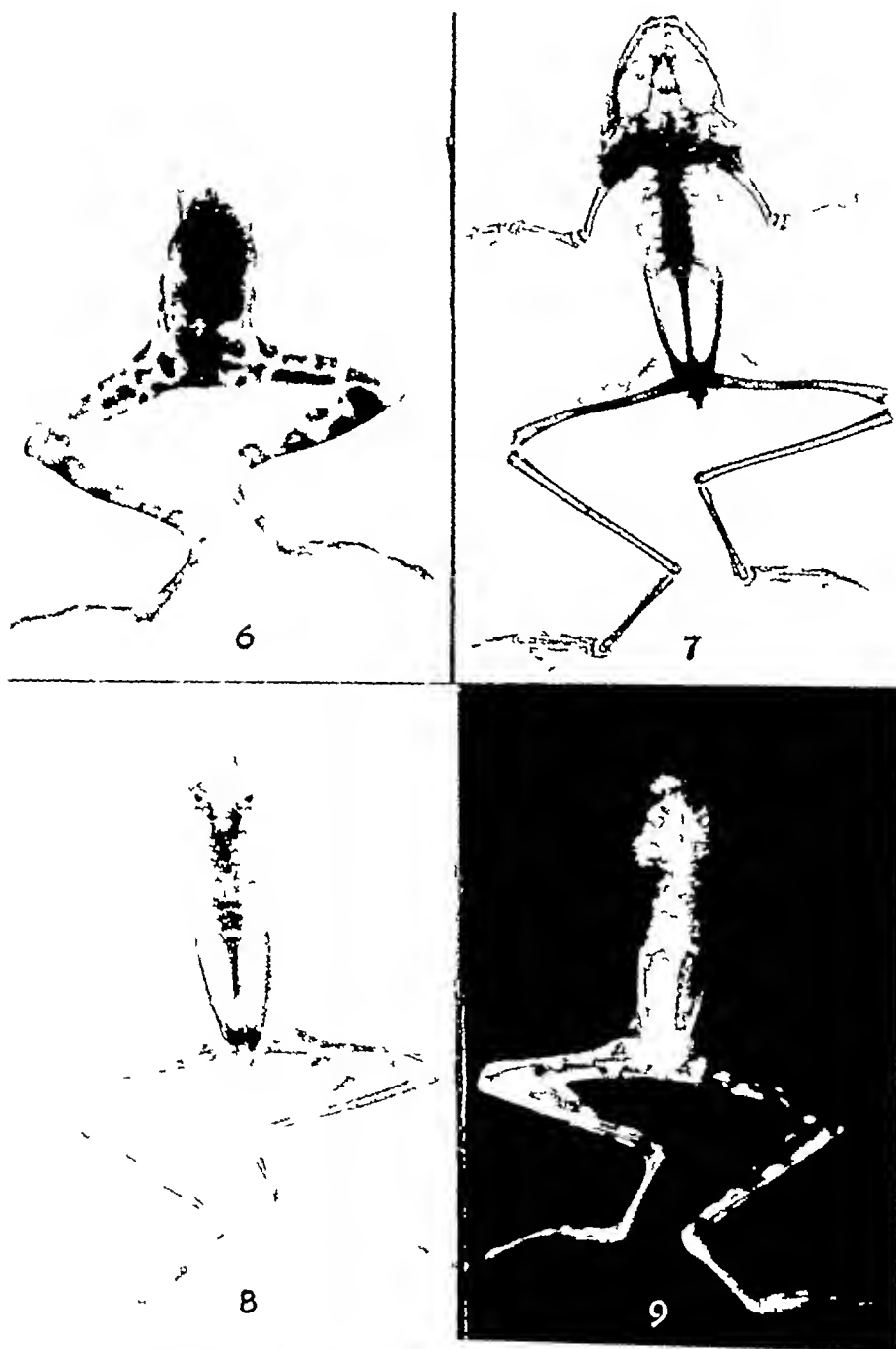


Fig 6 (upper left) Infra red photograph of a frog The same photographic technique was used Exposure time 10 seconds Contact print

Fig 7 (upper right) Roentgenogram of a frog taken under the same conditions as Figure 6 Contact print

Fig 8 (lower left) Infra red roentgen photograph of a frog taken under the same conditions as Figures 6 and 7 but exposed to the roentgen ray and to light simultaneously for 10 seconds Contact print

Fig 9 (lower right) The negative used in Figure 8 was rephotographed and then a print made

sulting image shows all of the detail of that side of the moth which is in contact with the emulsion of the plate and directed away from the source of radiation passing through the filter (Fig 2) It is to be noted that there is also evidence of some penetration as seen in the regions where the wings of the moth overlap

Figure 3 is a roentgenogram of the moth placed in the same position on the plate as that shown in Figure 2 Due to lack of density in the wings, no image of the wings is obtained with the ordinary roentgen apparatus Thus, only the image of the body of the moth is recorded on the plate

Figure 4 is obtained by placing the moth in the same position on the plate as in Figures 2 and 3 Light from an incandescent tungsten bulb, and the roentgen ray is directed through the filter simultaneously The result is a simultaneous infra-red roentgen photograph Figures 2, 3, and 4 are contact prints made from the original plates In Figure 5 the plate used in Figure 4 was rephotographed and then a print made

Figures 6, 7, 8, and 9 demonstrate the infra-red roentgen effect obtained in the frog

In attempting to explain this photographic phenomenon it is interesting to note the following observations

An invisible ray (infra-red) which passes

through an opaque filter possesses properties of both penetration and reflection

Intense heat from a hot plate when used instead of ordinary light does not activate the emulsion

When a sheet of paper is interposed between the emulsion and the object the same effect is obtained with a longer exposure time This experiment apparently eliminates the factor of pressure as being the cause of these effects

Various effects of organic material together with a brief discussion of the physics involved in this problem, are discussed in a paper now in preparation

#### CONCLUSIONS

With the use of the infra-red plate in conjunction with a material which filters out all of the visible spectrum but which is very permeable to the infra-red wave length sensitivity of the infra-red plate, simultaneous infra-red roentgen photographs can be made

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# ROENTGEN ASPECTS OF CONGENITAL APLASIA OF LUNG

By JOSEPH F ELWARD, M D, Washington, D C

THIS exceedingly rare condition has been variously designated as agenesis of high or low degree, aplasia, absence or defect in whole or in part of either lung, the choice of a descriptive term having depended largely upon whether or not a rudimentary bronchus or aplastic lung could be demonstrated. Accordingly, in 1912, Schneider (1) proposed a classification of pulmonary anomalies of this type upon that basis.

Although it occurs most commonly in newborn infants, many of them non-viable, since duration of life is in such case very brief, the anomaly has been encountered in individuals ranging in age from eight to seventy years. In fact, Heerup (2), in 1927, reported a case in a woman of 72, believed to have been the oldest patient with the condition thus far observed. The left side especially is affected, according to an analysis of 22 cases conducted by Levy (3), in the proportion of approximately two to one, a preference which cannot be accounted for on anatomical grounds. Except for one instance of bilateral absence of the lungs in a fetus of eight months, reported in 1893 by Schmit (4), in all cases only one side has been affected. Apparently the anomaly displays no predilection for either sex. In 10 cases of a total of 24 collected by Finner (5) in 1932, there was complete absence of one lung and every trace of bronchus on the defective side, while in seven other cases there was no sign of a lung but there was a rudimentary bronchus, the latter terminating in a small nodule regarded as an undeveloped lung in three instances. Four cases presented nodules resembling embryonal pulmonary tissue. On rare occasions recorded by other observers the lung appeared rudimentary in the extreme, sometimes varying in size from a millet seed to a buckshot.

Interference with the blood supply in

early embryonal life seems to have been assumed as the underlying cause of the anomaly in the majority of cases thus far reported in the literature. Hypoplasia due to fetal atelectasis has been advanced as a tentative etiological hypothesis by certain investigators. Encroachment by an enlarged thymus gland in the earliest embryonal stage, with consequent constriction of the anterior abdominal cavity, has been suggested by others as a possibly important factor in the etiology of the condition.

While a clinical diagnosis *intra vitam* of the absence of a lung is regarded as possible by some writers, among them Meyer (6), who, in 1910, reported his observations on an apparent case of aplasia of the left lung in a man of 27, in which the clinical diagnosis is said to have been confirmed by roentgen-ray examination, thus far there seems to have been no evidence of proof of a clinical diagnosis by subsequent autopsy. As Ellis (7) points out, compensatory enlargement of the existing lung appears to indicate the presence of pulmonary tissue with its physical signs on the side of the absent organ, thus affording no suggestion to the clinician of the lack of an entire lung. Moreover, the extreme rarity of the condition renders its clinical recognition improbable. In all of the 19 cases assembled by Ellis, the chest appeared symmetrical externally, the opposite lung, heart, or fluid replacing the missing organ, while in one case part of the intestines was found in the thorax.

Recorded instances of attempts at roentgen-ray diagnosis *intra vitam* are comparatively rare. Meyer (6) and Chilaiziti (8), in 1910, reported tentative radiological diagnoses of pulmonary aplasia in living subjects. Bönniger (9,10) subsequently presented roentgenologic evidence of congenital absence of the lung in two live males, aged 37 and 27, respectively.

Gilkey (11), in 1928, and De Toni (12), in 1934, reported cases of absence of the right lung in a male and in a female child, aged six and four months, respectively, in both of which the roentgen-ray diagnosis was confirmed at autopsy.

Acquired aplasia should be carefully differentiated clinically from congenital aplasia, the thorax usually exhibiting a sunken aspect in the former, while in the latter the other lung generally hypertrophies and prevents sinking, the chest, therefore, remaining symmetrical. Pulmonary aplasia should likewise be differentiated roentgenologically from postnatal (partial) atelectasis and also from atresia.

In all cases of congenital absence of the lung thus far described, autopsy has revealed (a) hypertrophy (emphysema?) of the other lung, (b) absence of hypertrophy of the right heart, (c) malformation of the cartilaginous skeleton of the trachea, and (d) other abnormalities (for example, auricular appendices, absence or maldevelopment of pulmonary vessels, alobular and multilobular lung on the opposite unaffected side, respective dextrocardia or sinistocardia, *et cetera*).

The following case from the author's own practice forms an additional contribution to the relatively small group in which the radiological diagnosis was substantially confirmed at autopsy.

#### HISTORY OF CASE

A white male patient, aged 43, was first seen on Oct. 17, 1934, with a concurrent history of paroxysms of dyspnea of from 20 to 30 minutes' duration for one week previously, these gradually increasing in severity up to the time of admission. There was a past personal history of pneumonia of two weeks' duration some nine months previously, mild asthmatic attacks of from two to three days in length shortly thereafter and again about five months later, a wheezing type of respiration ever since the pneumonia, and a particularly severe attack of dyspnea two months prior to admission, also a

more remote history of occasional violent cough dating back ten years. Inquiry into the patient's family history elicited the information that physicians had repeatedly told his mother (who died of pulmonary tuberculosis) that he would not grow up on account of the condition of his lungs.

Physical examination revealed a moderately well developed, fairly well nourished white man. Examination of eyes, ears, nose, and mouth proved negative. The chest appeared fairly well developed, with a marked lag of the left side from apex to base of lung. There was no bulging or retractions of interspaces, and no friction rub over either side. Vocal fremitus was increased over the left side from the base to approximately the third rib above. On inspiration and expiration marked rhonchial fremitus was felt posteriorly between the third and fourth ribs near the spine, while vocal fremitus was increased above normal throughout the right chest. On percussion, the left lung presented markedly decreased resonance (almost flatness) between the fourth and eighth ribs, both anteriorly and posteriorly. There was normal or slightly increased resonance on the left side from the apex to about the third rib. The right chest presented a normal percussion note throughout. Breath sounds were not heard over the left chest, either anteriorly or posteriorly, from base to apex, on account of loud adventitious sounds. Voice sounds were diminished over the left chest, but were normal on the right side. Breath sounds were bronchial and bronchovesicular at the apex and extreme base of the right lung, while loud gurgling râles and wheezing rhonchial breathing were heard over the left chest, and moist râles over the greater part of the right chest, anteriorly and posteriorly. Examination of the heart revealed an irregular apex beat lying past the left anterior axillary border about three centimeters past the anterior axillary line. There was no friction rub on palpation. The heart was markedly displaced to the left side, its right border beginning

at the left side of the sternum and the left border extending from two to three centimeters past the anterior axillary line

lapsed, but was evidently patent below its mouth, some thick, glue-like, non-culturable secretion having been aspirated there-



Fig 1 Case 1

Sounds were of fair muscular quality and irregular. No murmurs were audible on account of adventitious sounds from the chest. Examination of the abdominal organs and the extremities proved negative.

Bronchoscopic examination disclosed marked thickening of the right vocal cord, with normal movement of both cords. The trachea was deviated to the left and very narrow, hardly admitting an 8 mm bronchoscope. The tracheal mucous membrane was markedly injected. There was a small amount of mucopus in the trachea. The mouth of the left main bronchus appeared closed as though col-

lapsed. On reinsertion of the bronchoscope five minutes after its removal for relief of cyanosis, a little more thick secretion was aspirated.

A tentative diagnosis of atelectasis of the left lung, stenosis of the entrance to the left main bronchus, left deviation of the trachea, mucopurulent tracheobronchitis, and malignancy of the left lung was recorded. Following a second bronchoscopic examination two days later, with essentially the same result, but with appearance of a tumor mass pushing against the wall and causing partial closure of the slit-like opening of the left bronchus, a

Gilkey (11), in 1928, and De Toni (12), in 1934, reported cases of absence of the right lung in a male and in a female child, aged six and four months, respectively, in both of which the roentgen-ray diagnosis was confirmed at autopsy

Acquired aplasia should be carefully differentiated clinically from congenital aplasia, the thorax usually exhibiting a sunken aspect in the former, while in the latter the other lung generally hypertrophies and prevents sinking, the chest, therefore, remaining symmetrical. Pulmonary aplasia should likewise be differentiated roentgenologically from postnatal (partial) atelectasis and also from atresia

In all cases of congenital absence of the lung thus far described, autopsy has revealed (a) hypertrophy (emphysema) of the other lung, (b) absence of hypertrophy of the right heart, (c) malformation of the cartilaginous skeleton of the trachea, and (d) other abnormalities (for example, auricular appendices, absence or maldevelopment of pulmonary vessels, alobular and multilobular lung on the opposite unaffected side, respective dextrocardia or sinistocardia, *et cetera*)

The following case from the author's own practice forms an additional contribution to the relatively small group in which the radiological diagnosis was substantially confirmed at autopsy

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and fluid roentgenographically is not difficult. Clinically, however, the physical findings are the same, that is, absence of resonance and breath sounds over the affected area. Pleural puncture yields fluid in cases with effusion, high manometric readings in atelectasis, and no readings at all in cases of thickened pleura (Dubrow, 14).

The roentgen signs in pulmonary aplasia are symmetrical thorax, the intercostal spaces not being narrowed. The unaffected lung may be compensatorily hypertrophied (emphysema) and herniated through the mediastinum, which will explain the physical signs of normal lung usually found in the upper portion of the affected side and also the radiolucency in the same location. The roentgen diagnosis, if made at all, must be made by the elimination of all conditions noted as causes of the roentgen findings simulating the classic picture of atelectasis, and the positive signs listed under pulmonary aplasia.

1726 Eye St., N. W.

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supplementary diagnosis of mediastinal tumor was made

Roentgen examination on the same day led to a radiological diagnosis of atelectasis (so-called massive collapse) of the left lung, pneumonia of the upper lobe of the right lung, and old fibrosis with calcification throughout the right lung. At the same time a clinical diagnosis of massive collapse of the left lung was made.

The patient died on his third day of observation. Autopsy revealed apparent normal general relationships of the abdominal viscera. In the thorax, however, the heart filled practically the entire left pleural cavity, the lung on this side being only rudimentary in character, reduced in size to a small fibrotic mass firmly adherent to the posterior chest wall in the midline region. It was delivered with difficulty, measured three inches in length, one and a half inches in width, and one inch in thickness, and on palpation proved definitely fibrotic without evidence of air-bearing parenchyma. The bronchi, incarcerated in a mass of adhesions, suggested the so-called "bag of worms" beneath the pleural coat. The left bronchus was slightly reduced in caliber, measuring 1 cm in diameter at the hilus, with a definite kink 1.5 cm distal to the bifurcation, and posterior thereto a dilatation filled with a viscid, mucopurulent plug, the bronchus extending into the lung for a short distance, and ending abruptly in a series of small, sclerotic, partially occluded terminal branches. The left pulmonary artery was markedly diminished in size, measuring 5 cm at its entrance into the lung. There was no evidence of tuberculosis, infarction, or neoplastic change. The right lung was markedly hypertrophic and filled the pleural cavity completely, extending over the mediastinum, covering the heart, and protruding for a short distance into the left pleural cavity. The heart was markedly enlarged and pushed considerably toward the left as already described.

*Anatomical Diagnoses*—Hypertensive heart disease with congenital aplasia of the left pulmonary artery and left lung, com-

pensatory hypertrophy of the right lung with passive congestion and edema, hypertrophy and dilatation of the heart with hydropericardium, bilateral fibrous pleuritis, congenital elongation of the left auricular appendix with thrombosis, marked passive congestion of the gastrointestinal tract, incipient passive congestion of the liver, chronic interstitial splenitis, passive congestion of the kidney (left), with infarction.

The antemortem diagnosis of congenital aplasia of a lung is difficult. The similarity of the roentgenographic evidence in aplasia and atelectasis is marked. For this reason the roentgen findings in these conditions may be summarized as follows. In atelectasis there will be a sharply defined area of density corresponding to the lobe or lobes involved. The diaphragm on the affected side will be high and fixed. The heart and mediastinum will be displaced to the affected side. It should be remembered, however, that the following conditions may also produce this phenomenon:

- 1 Croupous pneumonia of an entire lung
- 2 Unilateral tuberculosis with fibrosis and pleural thickening
- 3 Unilateral pleural effusion when the mediastinum is fixed
- 4 Thickened pleura and stiffened mediastinum following the use of gomenol in oleothorax

In atelectasis there are also narrowings of the intercostal spaces on the affected side (asymmetrical thorax) and compensatory emphysema of the unaffected lung. The atelectatic shadow brightens and increases in size on forced expiration and decreases in size on forced inspiration (Kreutzfuchs' phenomenon) in the upright position. Basal atelectatic shadows also brighten on forced expiration in studies made with the patient lying on the unaffected side.

Large areas of atelectasis frequently occur in chronic lung disease, Korol (13) reporting cases of carcinoma of bronchus, interlobar effusion, pulmonary abscess, aortic aneurism, and bronchiectasis in which atelectasis occurred. Usually the differential diagnosis between atelectasis

and fluid roentgenographically is not difficult. Clinically, however, the physical findings are the same, that is, absence of resonance and breath sounds over the affected area. Pleural puncture yields fluid in cases with effusion, high manometric readings in atelectasis, and no readings at all in cases of thickened pleura (Dubrow, 14).

The roentgen signs in pulmonary aplasia are symmetrical thorax, the intercostal spaces not being narrowed. The unaffected lung may be compensatorily hypertrophied (emphysema) and herniated through the mediastinum, which will explain the physical signs of normal lung usually found in the upper portion of the affected side and also the radiolucency in the same location. The roentgen diagnosis, if made at all, must be made by the elimination of all conditions noted as causes of the roentgen findings simulating the classic picture of atelectasis, and the positive signs listed under pulmonary aplasia.

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# A CARBOHYDRATE MEAL INSTEAD OF THE FAT MEAL IN CHOLECYSTOGRAPHY

By J L KESTEL, M D , *Waterloo, Iowa*

**A**NTONUCCI (1), in 1933 reported the so-called rapid method of cholecystography, accelerated by the administration of glucose and insulin with the tetraiodophenolphthalein. By this method, concentrated gall-bladder shadows were obtained in two or three hours. In 100 of Antonucci's cases that had subsequent operative control, Zappala (2) reported no errors. Biedermann and Becher (3) reported good shadows in two or three hours when 75 grams of glucose were given orally

advantages, procedures to improve the quality of the cholecystograph were attempted.

In several instances when relatively faint shadows were obtained, the patients were given a carbohydrate meal instead of the customary fat meal. Two hours later, a slightly smaller, but considerably denser gall-bladder shadow was obtained in each instance. This procedure was then adopted as a routine to replace the fat meal. In 14 of 30 cases, a heavier, smaller shadow was



Fig 1-A

Fig 1-A Case 1 Radiograph after two-dose oral administration



Fig 1-B

Fig 1-B Case 1 Gall bladder reduced in size and intensified two hours after carbohydrate meal

45 minutes before the intravenous administration of the dye. However, Tu-Shan Jung and Sherwood Moore (4) failed to obtain shadows more rapidly, or to improve the quality of the cholecystograph by the oral administration of glucose. Dye retention was invariably reduced and the reaction of the patient to the dye was minimized. As the dye left the blood stream more rapidly, it seems strange that neither earlier nor better shadows were obtained. Believing that glucose must have some

obtained after the carbohydrate meal. In eight cases the shadow was as intense, although reduced in size. (Considering that the volume of the gall bladder was reduced and the relative concentration of the dye higher, negative shadows surrounded by this medium would be more clearly visible.) Of the remaining eight cases, two showed little change in the shadow, in three it was smaller and fainter, and in the remaining three it had disappeared completely. In one instance, a shadow was visualized after



Fig 2 A

Fig 2-A Case 2  
Fig 2-B Case 2



Fig 2 B

Faint large gall bladder shadow after two dose oral administration  
Denser smaller cholecystograph after carbohydrate meal

the carbohydrate meal when it had not been present before

While the results have not been perfectly uniform, it is certain that the procedure has advantages over the radiograph after a fatty meal. The value of the emptying rate of the gall bladder is questionable. Tetraiodophenolphthalein leaves by the same channel through which it entered, namely, the cystic duct. (No shadow is obtained if any portion of the common duct is occluded.) It cannot be compared to the value of determining the emptying time of the stomach. It might be considered an index of the contractility of the gall-bladder wall, but if the gall bladder is capable of producing a concentrated shadow, its walls cannot be seriously diseased. Usually the carbohydrate meal is also followed by some reduction in size of the original shadow. With the smaller shadow of relatively increased density, stones or other negative shadows might be discovered when overlooked in the original radiograph. In this way it has an advantage over giving carbohydrates with the dye.

The following routine has been adopted for the average weight individual: a meal at noon devoid of fats is followed in 30 minutes by two and one-half grams of dye. The evening meal at 6:30 P.M., consisting largely of carbohydrates, is again followed by two and one-half grams of dye. Fruit juices are allowed during the first hour after either administration of the dye. The first radiograph is taken the following morning at 8:30 and is followed by a carbohydrate meal. This meal consists of two slices of toast with jam or jelly, a glass of orange juice, and either tea or coffee with sugar. The second and last radiograph is taken two hours later.

Faint or absent shadow cases are given the carbohydrate meal and repeated two hours later. If the patient has vomited part of the dye or developed diarrhea after the administration, and the carbohydrate meal fails to intensify the shadow adequately, the cholecystograph is repeated after the intravenous administration of the dye. A second radiograph is again taken two hours after a carbohydrate meal. If there is any question of slight motion in a

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# KOHLER'S METATARSAL DISEASE

WITH A CASE REPORT

By STAKELY HATCHETTE, M D, *Lake Charles, La*

**K**OHLER'S disease of the metatarsal is a condition which most commonly affects the second toe and its metatarsal, though it may rarely affect the other toes and their respective metatarsals. According to Kohler,<sup>1</sup> it is characterized by the following:

(1) A change in the shadow contour of the articular surface of the proximal head of the proximal phalanx, as seen in antero-posterior or postero-anterior views. In normal bones the contour is that of a regular arch, while in Kohler's disease the contour is somewhat irregularly extended, and in many cases is approximately S-shaped.

(2) The articular fissure is usually broader than normal, which is helpful in distinguishing it from an arthritis, for in an arthritis (except those with effusions) the total changes are considerable and are always accompanied by a narrowing of the articular fissure, resulting from erosion or shrinkage of the articular cartilage.

(3) The articular fissure is not only wider and deeper than normal, but shows considerable variation and is broadened irregularly, the lateral half of the fissure often being as much as twice the length of the medial half.

(4) The articular head of the metatarsal loses its rounded shape, recent cases show only more or less flattening, while long-standing cases show irregular rounded protuberances of the head separated by intervening defects.

(5) In long-standing cases with marked changes there is a shadow of the density of bone, circular in shape and extending from the lateral aspect of the articular fissure out into the soft tissues.

(6) The distal third of the head of the metatarsal shows a definite shortening as if the articular cap were being compressed.

It is a peculiarity of this condition that only the distal third of the head shows this apparent shortening, as a consequence of which, the whole metatarsal shows a shortening. In some cases the head of the metatarsal has the appearance of the articular portion having been pressed in and then separated, so that it is conceivable that it might be mistaken for a fracture.

(7) In all pronounced cases of this condition there is a distinct alteration of the entire distal half of the metatarsal. This is manifested by the circumference of the bone beginning to increase at about the middle of the shaft and showing a gradual accentuation of this phenomenon out to the distal end, so that there is no indication of a neck, and the distal half of the bone bears a strong resemblance to the proximal half in form and size. Both the marrow cavity and the cortex of the bone become broader as the distal end of the bone is approached, though the cortex becomes reduced to normal size at the head. A feature which distinguishes this condition from osteomyelitis and spina ventosa is the gradual and uniform increase of the bone distally, and the fact that the structure of the spongiosa is apparently regular and definite as far as the articular cap.

Kohler reports that about one hundred cases of this condition were obtained by him from the literature and private communications up to August, 1927, and while this does not permit the classification of this disease as being rare, yet it is relatively uncommon. He states that in a series of ten cases the second metatarsal alone was affected in nine, and the third metatarsal alone or along with the second metatarsal was affected in one. In two of these cases both feet were affected. The age incidence is from 10 to 48 years in his series, and he states that in cases over 18 years of age the condition is never recent, but usually origi-

<sup>1</sup> Kohler, Alban. Roentgenology. William Wood & Co. New York, 1931.

radiograph, it is repeated. In the small number of cases examined by this method, no errors have been detected.

It was thought that perhaps the carbohydrate meal had advantages over glucose alone. The galactose tolerance test is more reliable in the determination of the liver function than the glucose curve. The variety of monosaccharids formed in the metabolism of such a meal might have a more stimulating effect upon the liver.

Glucose could, in part at least, be utilized directly by the tissues. In a few cases tried with glucose, however, the results were practically the same.

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-

of the patient putting on his shoes, and every night when the shoes were removed. On each occasion the pain has lasted for

tive of such. The Kahn and Wassermann tests were negative. He was not able to recall just when he first noted pain in his



Fig 2 Showing an oblique view of the left second metatarsal and a lateral view of the same bone. In the lateral view, the bony overgrowth at the distal head is seen to be the cause of the swelling on the dorsum of the foot.

approximately half an hour, at the end of which time he has been comparatively comfortable. He has also suffered great discomfort and pain when he has attempted to walk any distance, and has had to quit several jobs that have required his standing on his feet for any length of time. He has just recently returned home from an attempted enlistment in the Navy, having been rejected at the recruiting center as "physically unfit because of a painful foot."

The family history was unimportant. His past history included the usual diseases of childhood, such as measles, whooping cough, chicken pox, etc., but nothing at all unusual in this line. He denied venereal disease, and there was no evidence sugges-

left foot, but stated that it must have been when he was about fourteen years old. The only cause to which he could attribute it was having stuck a splinter in the bottom of his foot when he was about six years old, but he stated that the splinter did not go in deeply and that it was removed by a physician without any trouble. From the time he first noted the pain until the present, it had been gradually getting worse, so that while in the past, he has had jobs such as delivering handbills, clerking in small grocery stores, etc., he stated that he is no longer able to hold any job requiring walking or standing for long at a time. When he was 18 years old he noticed for the first time that there was a hard swelling begin-



nates in the growing period and passes unnoticed until examined. Over two-thirds of all cases occur in patients from 10 to 18

foot in the region of the second metatarso-phalangeal joint and tenderness on pressure. This tenderness is usually present on



Fig. 1 Showing the normal second metatarsal of the right foot as compared to the pathologic condition involving the second metatarsal of the left foot

years of age, and the condition is four times as common in females as in males. It is twice as common in the right foot as in the left.

Clinically, the condition is manifested by pain in the region of the second metatarso-phalangeal joint. This is particularly noted on application of pressure to the foot, or removal of pressure. The effects upon the gait are such that the patient refrains from using the foot any more than is necessary. Objective symptoms consist of swelling of the soft tissues on the dorsum of the

both dorsal and volar aspects, though may be dorsal or only volar. Pain on motion is less common. There is no redness or fever connected with the swelling, and no pronounced signs of inflammation are present.

#### HISTORY OF CASE

A. J. B., aged 21 years, white male, unemployed at this time, complained of pain, varying from severe to dull on different occasions, at the second metatarso-phalangeal junction of the left foot. The pain was brought on every morning as a result

# SOME PHYSICAL ASPECTS OF THE 650 KV CONSTANT POTENTIAL X-RAY APPARATUS AT THE LINCOLN GENERAL HOSPITAL

By T R FOLSOM, MS, Memorial Hospital, *New York City*

Formerly Physicist, Lincoln General Cancer Clinic, Lincoln, Nebraska

THE 650 kv constant potential x-ray apparatus, installed at the Lincoln General Hospital in September, 1933, has given daily service in cancer therapy since that time. The equipment has many unique features, and has undergone several alterations toward the end of clinical con-

tical, end grounded porcelain tube similar to the original Lauritsen design. A seven-stage rectifier assembly supplies the constant potential applied to the tube. The anode is of the multiple portal style and is at ground potential and shielded with one inch of lead.

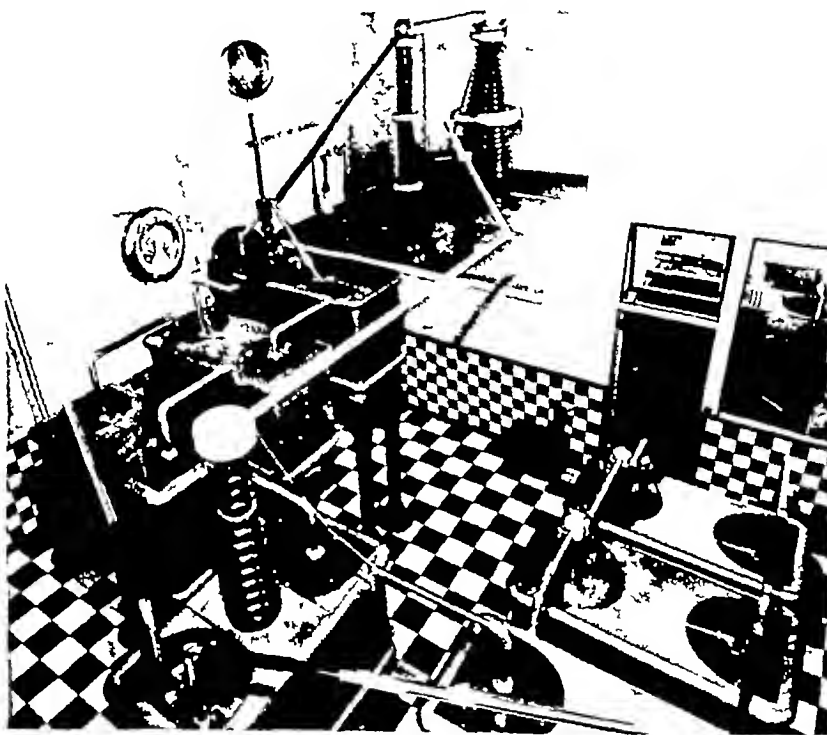


Fig 1 General view of high voltage equipment with porcelain tube in background

venience and reliable and economical maintenance. A description of the equipment as it now stands, and a discussion of some of its output characteristics and singularities of operation might be of interest to others in the same field.

The equipment<sup>1</sup> includes a nine-foot ver-

<sup>1</sup> Manufactured by the Kelley Koett Co

## INSTALLATION LAYOUT

The equipment is housed in an especially built wing of the Lincoln General Hospital. A view of the transformer room, the floor of which is 30 X 30 ft, ceiling 20 ft high, is shown in Figure 1. In the left background can be seen the leaded roof of the

ning on the dorsum of his foot. This caused pain on pressure, the pain being dorso-ventral. There has never been any redness or local increase in temperature involving this swelling. On removing the shoe, the pain immediately began and lasted, with gradually diminishing intensity, for approximately thirty minutes. Movement of the toe during the painful period did not cause an increase in its intensity, and movement of the toe after cessation of the pain did not cause the pain to return.

Physical examination of the foot revealed a moderate swelling in the region of the second metatarso-phalangeal joint, the swelling apparently being largely confined to the distal end of the metatarsal. It did not show any redness and was firm on palpation. No local fever was present. It was painful dorso-ventrally on pressure. Replacing the shoe resulted in the pain commencing again and it lasted for approximately the same time as after removal of the shoe.

*Radiographic Examination*—The right foot showed no roentgenologic evidence of pathology. All of the bones and joints of the left foot were normal with the exception of the second metatarsal and the proxi-

mal head of the proximal phalanx of the second toe. The anteroposterior view showed, at the proximal end of the phalanx mentioned, an irregularly extended, S-shaped articular surface. The articular fissure was slightly wider than normal and showed considerable irregularity and broadening, the lateral half of the fissure measured 1.3 cm. in length, while the medial half measured 0.9 cm. The articular head of the metatarsal showed three distinct hillocks, separated by intervening defects. The distal third of the head of the metatarsal was shortened and appeared as though the articular cap had been compressed. The entire distal half of the metatarsal showed an altered appearance manifested by a gradually increasing circumference of the bone from the middle of the shaft out to the distal end. The distal end showed no neck at all, it having been obliterated in the pathologic process involving the bone. Both the cortex and the marrow showed broadening distally, though the cortex became reduced to normal size at the head. The spongiosa was regular as far as the articular cap.

*Diagnosis*—Kohler's disease of the left second metatarsal.

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four feet from a full-potential electrode of similar shape

It was found that the electrostatic volt-

was made to the newer Apiezon oil pumps. The mercury pumps necessitated liquid air which cost about one hundred dollars per

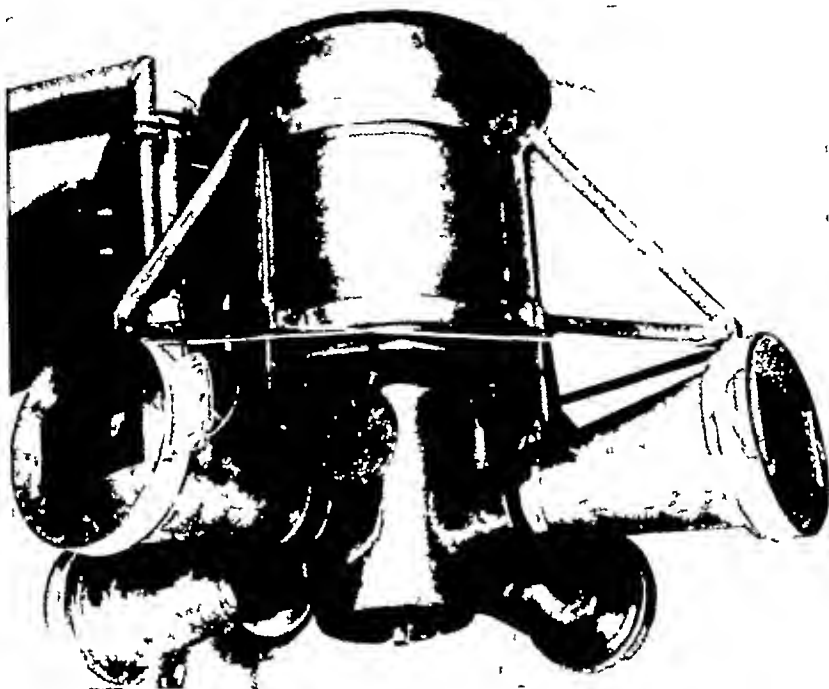


Fig 3 Shielded anode, showing four treatment cones, and the high vacuum pumps. The cones have transparent end windows which may be rotated about the axis of the beam.

meter was unable to detect the ripple in potential at 650 kv and 10 ma when the usual phase shifting test was made with the meter. The ripple, which must have been less than 0.5 per cent, was unexpectedly low but that is understandable when the effect of the long cascade of insulating transformers is considered. The manufacturer's oscillograms show that each unit has a ripple of about 3 per cent on 10 ma load, but the various units are supplied with alternating current which is progressively out of phase at each unit because of the loose coupling in the transformer windings. This causes the seven small, out-of-phase, 3 per cent ripples to add together into a much more smooth constant potential.

#### VACUUM SYSTEM

After five months of operation with mercury high vacuum pumps, a conversion

month, and which had to be shipped from several sources up to 200 miles distant. Delay meant shut-down and contamination. Dry ice and acetone were found insufficient as a refrigerant for the traps.

The first Apiezon pumps were built after the design of Lauritsen and Crane, and were found faster for their size than the previous mercury pumps. These earlier pumps were of 6-inch diameter.

However, a peculiar discharge haunted the tube at this time, which led to the implication that the Apiezon oil, used without any trap, as Crane and Lauritsen used it, might be diffusing into the tube in small quantities. The matter was investigated by building a new three-stage oil pump which was better cooled, and, in addition, a large baffle type of charcoal trap. This trap could be heated to redness while the tube was closed off by a valve and then cooled with a water jacket while pumping.

treatment room. The latter has walls of 24-inch concrete and is below the earth level. Its floor space is  $14 \times 14$  ft, and the ceiling height is 7 feet. The porcelain

tube, seen in the far background of Figure 1, is supported by the treatment room ceiling. The leaded steel anode tank, carrying the target, the four lead treatment cones, and the two high vacuum pumps, extends through the treatment room ceiling, as can be seen from Figures 2 and 3. The treatment cones are 47 inches from the floor, and give four beams simultaneously of the same quality and quantity in the four cardinal directions. The patients are raised to the cones on hydraulic tables and arm chairs.

Through the window on the right of Figure 1 can be seen the control room, which is in communication with the treatment room by means of a large periscope in the intervening wall.

#### HIGH VOLTAGE APPARATUS AND CONTROLS

The seven corona tanks seen in Figure 1 each contain a 100 kv, 30 ma voltage-doubling type of rectifier unit, which units are insulated from the ground by porcelain tubes of appropriate height, the longest being 6 feet. They are supplied by a cascade of seven insulating transformers, also contained in the tanks. The potential is controlled by a tapped-secondary type of voltage-regulating transformer supplying the power cascade. The regulator is operated remotely from the control panel.

The filament of the tube is supplied at high potential by means of a cascade of six insulating transformers contained in the slender column in Figure 1 near the tube. The corona rings seen in the figure and a 5-inch diameter bus connecting the tube were found necessary to keep the corona losses down to about 0.3 ma at 650 kilovolts. No visible corona exists except at the top of the tube, and there it amounts only to a few one-inch-long "whiskers."

A 50 cm chromium-plated sphere can be seen in Figure 1, its mate can be lowered from the ceiling by a motor-driven lead screw controlled on the switch board. On the left hand wall can be seen the blades of the synchronous electrostatic voltmeter and its corona shield. The latter is about

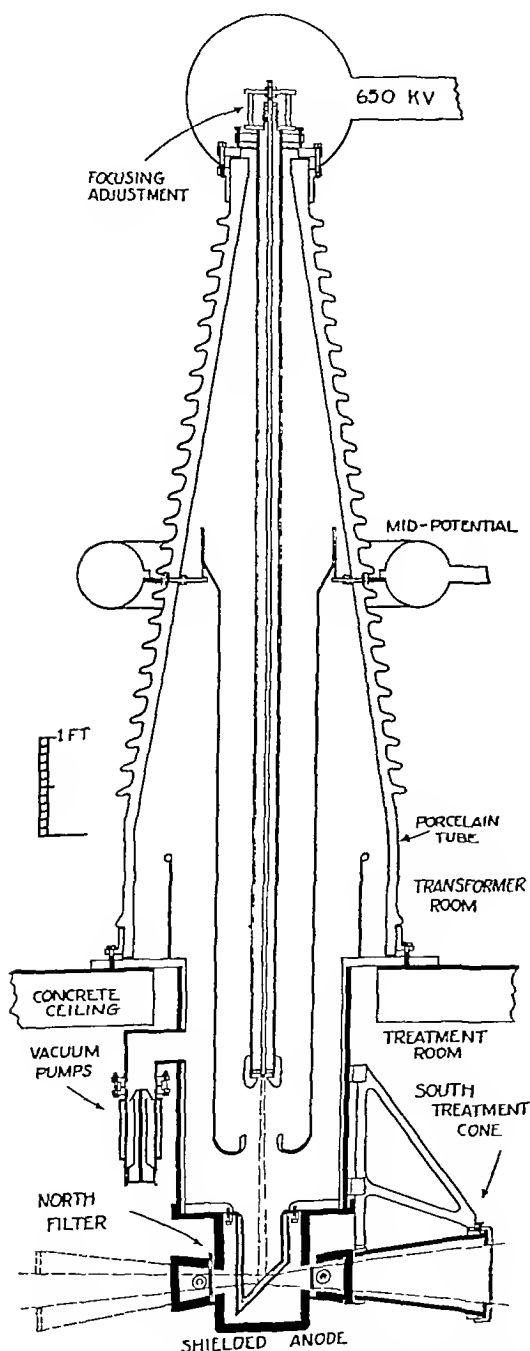


Fig 2. Vertical section of tube showing two portals only. Actually, the target plane is not as shown but rotated 45 degrees about a vertical axis.

trode, connected to the mid-potential of the rectifier, was installed in the tube. This screens off bombardment of the steel by the full potential discharge and redistributes the potential toward a somewhat more favorable gradient. The cylinder is rolled from ordinary 16-gauge steel and merely sand polished and is probably too rough. In the neighborhood of 700 kv, the discharge is now about the same as it was formerly at 500 kv and is equally probable between the inner and outer fields. Focusing is not difficult with this electrode, a cone in the cathode ball contains  $\frac{1}{4}$  inch diameter pancake filament which can be adjusted by means of a "slyphon" at the top of the tube. A focal spot of about three centimeters diameter is customary.

It might be pointed out that in case very complete x-ray protection is essential in the vertical direction, this might be very effectively obtained by making the cathode wall as well as the bottom plate on the mid-potential electrode (Fig 2) of the heavy tungsten-in-nickel alloy described by Read (1) or of other heavy metal. Complete protection in all directions is more difficult in other types of tubes and requires tons of lead on distant walls.

#### TARGET, FILTERS, AND TREATMENT CONES

The anode was designed so that four patients might be treated simultaneously. However, the desirability of having all four beams identical in quality as well as in intensity was soon realized, and an effort was made to accomplish this. As will be seen from Figure 2, two of the beams come from the face of the  $45^\circ$  inclined target and two beams must penetrate the target. In Figure 2 only two beams are shown, one of each type, in reality, however, the four beams emerge at  $45^\circ$  angles from the intersection of the target and the horizontal plane. Because of this angular penetration, the thick gold or tungsten targets and their supporting slab of copper and solder caused the two target-penetrating beams to be heavily, though indeterminately, filtered. To correct this, a thin copper target, electroplated with  $\frac{1}{100}$  inch of lead, was



Fig 4 Showing exaggerated demonstration of the use of illumination to outline the treatment beam. Normally the patient is placed close to the cone.

developed and found very satisfactory. Up to 10 ma at 650 kv could be carried continuously on a focal spot of about one inch diameter. The target is surrounded with 1 cm of water held in a 3 mm thick aluminum jacket. A complete description of this use of lead for targets is published elsewhere (2). Using this target, with four beams filtered with 2 mm of lead, there is a quality difference due to the target filtering of about 0.3 mm of lead. This was found by making complete lead absorption curves of all four beams. This amount of lead is then added to the face beams and the small intensity difference is then corrected by adding copper filters. It will be noticed from the copper curves shown that very little *hardening* is obtained from copper after the beam is thus heavily filtered.

Secondary filters consist of 0.5 mm of tin plus at least 0.5 mm of copper, and 3 mm of celluloid. Aluminum-lined lead treatment cones, giving a 72 cm treatment distance, are seen in Figure 3. One-inch lead shutters close the beams not in use. The filters are placed as far as possible from the patient (Fig 2).

#### ILLUMINATION OF TREATMENT BEAMS

During the redesigning of the treatment cones, a simple scheme for making visible the exact course of the treatment beam was devised, which later proved extremely advantageous to the clinicians. Because the filters were situated in the throat of the

the tube. The net result was that no change in the discharge was noticed and the blame was removed from the oil. In fact, later investigation showed that the tube worked better, as it stood then, with a 0.1 micron vacuum rather than still lower—say, 0.005 micron. It was discovered that when the tube, operating at full potential, was disconnected from the pumps by a valve the stability and freedom from discharge current improved as the pressure built up. This took about 15 minutes and was terminated suddenly—a gas rush occurred when about 0.1 micron pressure was reached. A needle leak valve was then installed for a while to maintain an optimum vacuum, but was later discarded when changes in the tube electrodes made a higher vacuum necessary.

Recently the entire vacuum system was rebuilt at the laboratory to incorporate the information gained from experience. All rubber and wax seals were eliminated and replaced with lead gaskets squeezed with extra heavy bolts. Two small pumps of 4-inch diameter were placed directly next to the tube, as seen in Figure 3. The whole system, made of welded steel tubing, was designed in units which might be tested with 100 pounds air pressure under water at any time in case of a future leak.

The pumps are all shut off after treatments are concluded for the day and turned on an hour before treatments begin in the morning. If the tube has been opened to the air, a good running vacuum can be obtained again in less than three hours. About 300 watts are used by the oil pumps which are heated with percolator heating elements.

To cut down the pumping-out time, the backing-pump system was reduced in length and its diameter was increased to two inches. For the same purpose also the second stage pump was made with a diameter as large as the first stage high speed pump. The former has a  $\frac{1}{8}$  inch orifice and the latter a  $\frac{1}{2}$  inch one. Experience indicated that the most practical vacuum system for a short-gap tube of this type

vacuum and second stage system, and less emphasis on the high vacuum pumping speed. Such a tube gives off very little gas when running and requires a relatively poor vacuum. Cold emission discharge is apt to be much more of a limitation than is gas discharge. The pumps mentioned above apparently "take hold" at a pressure of several millimeters of mercury, a distinct convenience when there is such a large volume to exhaust.

#### TUBE DESIGN

Originally the tube was of the single acceleration type, the cathode ball being about nine inches from the bottom of the steel tank seen in Figure 2. At voltages of about 500 kv, a rapid succession of quickly extinguished discharges took place, the frequency of these bursts, but not their violence, increased with the voltage. At 600 kv these discharge bursts were so rapid that they produced about 5 ma of tube current regardless of the filament current and added to the latter. However, no electrode damage was ever noticed other than a slight "etching effect" on the cathode ball. Changing the shape and condition of polish of the cathode had no effect on this wild discharge. A dummy cathode, 2 ft shorter, was tested and gave the same discharge.

A heavy lead pinhole camera was placed so as to view the bottom and sides of the anode tank, through a conical hole in the lead shield, and several films were exposed for about an hour. The discharge was found to consist of hundreds of tiny bright spots on the inside of the steel tank. These spots moved at random and, what was more interesting, had no predominance at rough spots where higher field intensities would be expected.

As was previously mentioned, this discharge was discovered to be greatly diminished when the pressure was permitted to build up to about 0.1 micron. The conclusion drawn was that the discharge was cold emission and not gas discharge, and was screened or damped by the gas molecules in some way. Recently a cylindrical elec-

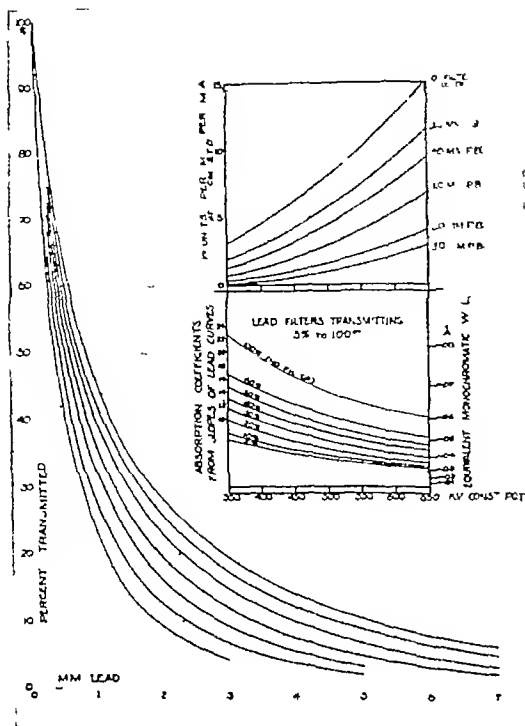


Fig 6

Fig 6 Percentage absorption curves for lead. Also intensity output and calculated absorption coefficients and equivalent wave lengths for various lead filters and voltages between 350 and 650 kilovolts

Fig 7 Copper absorption curves from constant potentials of from 300 to 650 kv made with open air chamber

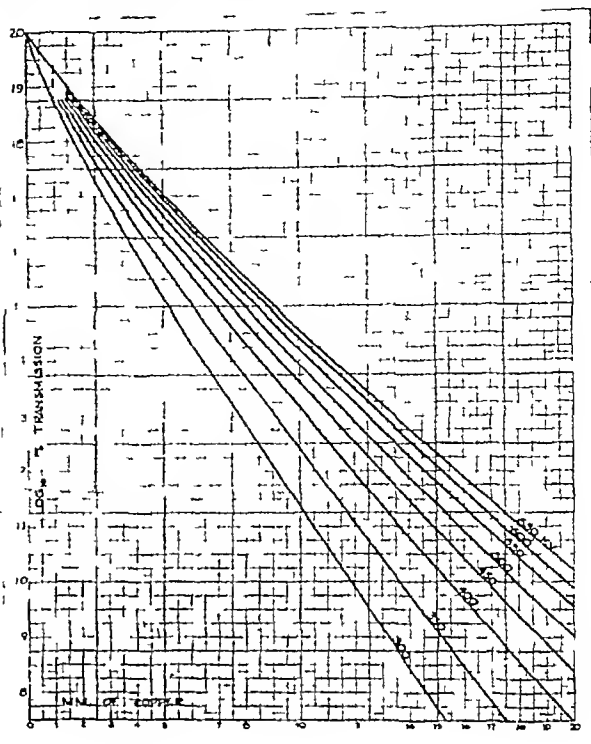


Fig 7

### ABSORPTION MEASUREMENTS

Figure 5 shows the absorption in lead of x-rays of constant potentials from 350 kv to 650 kv as measured by a large open air chamber. The inserted diagram in Figure 5 shows the experimental setup. A large parallel plate open air chamber was used whose spacing was 30 cm, the lower, high-potential plate was 73.5 cm long and 60 cm wide. The amber-insulated collector plate had an effective width of 14.12 cm, and extended the full width of the potential plate and guard plates. Carbonized threads, the potential of which was maintained by a resistance divider, were strung in levels 2 cm apart from the spacing posts on the corners. The lower plate was held at a potential of about 6,000 volts, which was about two times the saturation potential found for these intensities.

The ionization current was measured by means of a string electrometer and a con-

denser compensator loaned by Dr L S Taylor, of the Bureau of Standards. A seven-step lead filter wedge was used directly in front of the restricting diaphragm and could be shifted at will from a safe distance, as could the 4 cm thick shutter directly behind the restricting diaphragm. The tube was maintained at a steady potential throughout the measurement of the complete curve. The diaphragms were aligned by means of a silk thread, and penumbra measurements were made photographically. As is seen in Figure 5, three other rough-collimating diaphragms were used to restrict all but the collimated beam. The restricting diaphragm was 4 cm thick and had a hole tapered 4 degrees. The beam was taken from the face of the lead target, 45 degrees from its plane, and had to pass through 3 mm of steel, about 10 mm of water, and 3 mm of commercial aluminum jacket.

In earlier tests it was found that the



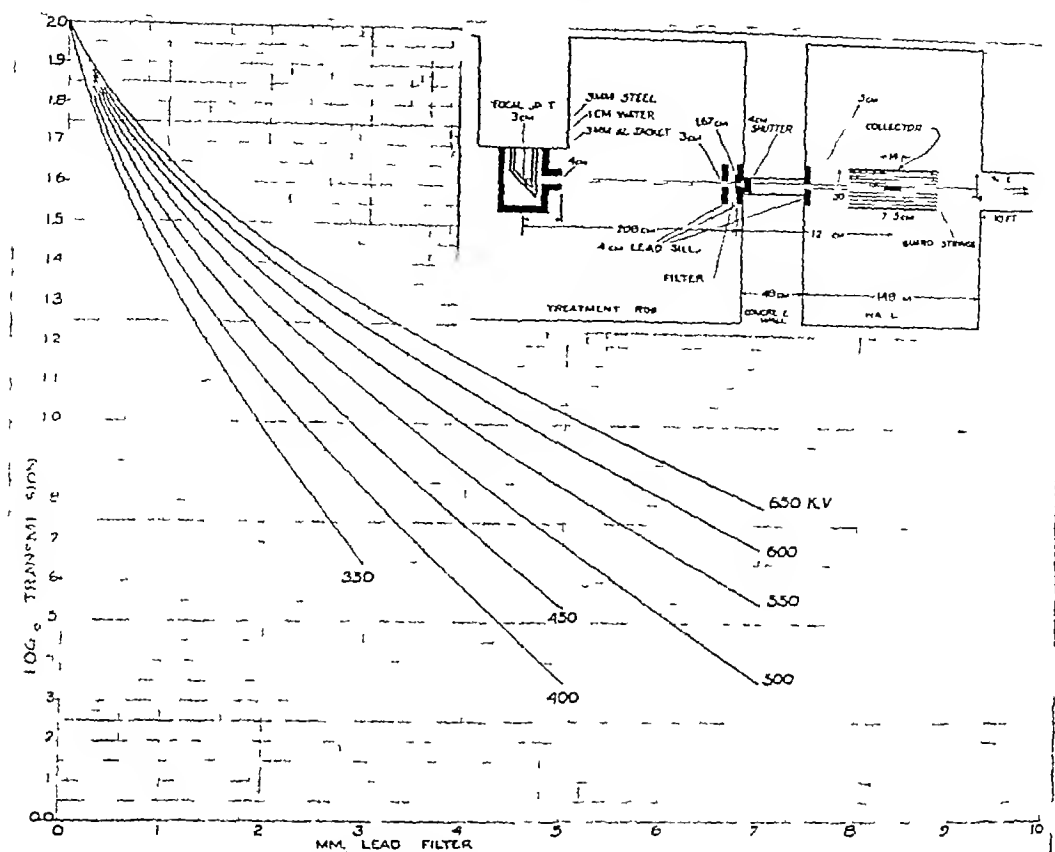


Fig 5 Absorption in lead of constant potential x rays of from 350 to 650 kilovolts Also experimental setup for using large open air chamber

cone and the limiting diaphragms were near the patient, it was found that by merely placing a 75 watt lamp in front of the filters a light beam which coincided with the x-ray beam, within a few millimeters, would be projected through the transparent celluloid at the end of the cone. The amount of filtering due to the light bulb was considered negligible. Figure 4 shows an exaggerated demonstration of the use of this beam with a patient. Normally the patient is close to the cone, however, even then the light beam is of value in outlining the intersection of the x-ray beam with irregular surfaces, as found on the shoulder. It was found that the clinician became more conscious of the overlapping problem when he actually saw the beam projected.

The above scheme was chosen because of its simplicity. However, it is evident that a more precise method for doing the same thing, even with closer treatment distances, can be devised with the help of a thin aluminum mirror placed between the filters and the limiting diaphragm at an angle of, say,  $45^\circ$  from the axis of the beam. Then if a light source of the same diameter as that of the actual focal spot used is placed as far from the mirror, say, to one side of it, as the focal spot is behind the mirror, the light beam can be made to follow the x-ray beam with any desired accuracy. The cone must obviously have a transparent window, clear celluloid answers this purpose admirably and also reduces diaphragm secondary scattering if made of sufficient thickness.

TABLE II — SPHERE GAP CALIBRATION DATA  
(WEIGHTED) 25° C, 760 MM ONE SPHERE  
GROUNDED

Gap Distance (cm)	Crest Negative Sparks (kv)
5.0	136
7.5	197
10.0	260
12.5	317
15.0	367
17.5	411
20.0	451
22.5	486
25.0	519
30.0	573
35.0	615
40.0	651
45.0	681
50.0	758

under consideration by the Committee on Standards of the A I E E of the spark gap data of several recent investigators. These data are considerably different from the 1928 A I E E standard (5) commonly used in the past in this country. For example, for a gap of 40 cm, the old A I E E data give 694 kv crest for either positive or negative sparks. Meador's more recent data give 635 kv negative crest, and the above weighted data give 651 kv for the same gap.

With the realization that the older sphere gap voltage standards for the higher voltages are now in a state of revision, the above provisional weighting was chosen and herewith included. The weighted points will probably be closer than the old points to the finally accepted standard, if a consistent standard ever is established. The measuring of the separate sparking distances for positive and negative potentials, as is implied by the more recent investigations, is not satisfactorily explained, especially with regard to constant potentials. Unfortunately, the sparking distance investigations in the higher voltages have all been made with alternating or surge potentials.

It seems that at present it is important that voltage data referred to sphere gaps should include an adequate description of the technic used and the configuration of the surroundings. Future salvage may then be possible.

As seen in Figure 1, the sphere gap used was between the ceiling and several high potential surfaces. The closest conductors were about three diameters from the spheres. The lower sphere is seven feet from the nearest wall and about seven feet from the ceiling.

An electrostatic rotary voltmeter was built shortly before the absorption measurements were made with the hope that this would solve the voltage problem. However, the behavior of this meter above 600 kv was dubious and it was not used as a standard. This did not prevent its being used as a very satisfactory voltage indicating device for maintaining constant voltage during long absorption measurement readings. Surges, load drops, and gas discharges are immediately indicated by the large scale deflections of such a meter, which makes it an invaluable aid when a tube is operated at near its maximum potential.

When calibrated at 300 kv against the sphere gap, the electrostatic meter followed the sphere gap curve within about 2 per cent up to 600 kv, but thereafter departed erratically. This was attributed to space charge due to the closeness of the collecting vanes to the high potential surfaces. There was, however, no visible corona near the meter.

A very satisfactory agreement between the sphere gap data of T. R. Meador and the readings of a rotary voltmeter calibrated at 8,000 volts has been found by Henderson, Goss, and Rose (7). However, the experience of Tuve and others casts serious doubt as to the reliability of such electrostatic voltmeters as standards at high voltages (6).

#### TREATMENT TECHNIC

The treatment technic adopted made use of 20-minute treatments at the intensity of 15 r per minute. The total customary dose to one skin field was from 2,000 to 3,000 r. Several skin fields were used, usually in rotation throughout the month-long series of treatments. The voltage is maintained near 625 kv and the filters, as mentioned

large chamber could not be used satisfactorily inside the treatment room. The distance was too short for proper collimation and the scattering from the walls made too great a background radiation. Even small scattering is multiplied several hundred-fold relative to the direct beam by such a chamber, and any adequate shielding around the chamber would weigh tons. To overcome this difficulty, a 48 cm thick concrete wall was drilled and 4 cm thick lead plates placed at both ends of the hole. The beam was restricted by the first diaphragm to fall within the area of these plates. Furthermore, to prevent scattering of the beam after its having passed the chamber, a 10 ft long tunnel was provided behind the chamber (Fig 5).

Figure 6 shows the values of Figure 5 in percentages to make intensity comparisons easier. The initial intensities in the absorption curves are obviously not the same but are shown in the upper inserted diagram. In the latter graph can also be seen the r per minute per milliamperere intensities at 72 cm distance when various lead filters are used on voltages from 350 to 650 kilovolts.

The lower inserted graph is included as a convenience to anyone wishing to compare the hardness of x-rays for different voltages when lead filters of from 100 per cent to 5 per cent transmission are chosen. The absorption coefficients are taken from the slopes of the absorption curves in Figure 5, and the monochromatic equivalent wave length scale is taken from recent data by M T Jones (3). It should be noted that these graphs consider beams coming directly from the lead filters, without any secondary copper or tin filters being used.

#### COPPER ABSORPTION CURVES

The copper absorption curves shown on Figure 7 were made in the same manner as the lead curves. A 300 kv curve is also included. The half value layers taken from the copper curves are shown in Table I.

TABLE I

Constant Potential (kv)	Half Value Layer, with Initial Filtering of Tube Alone (mm)	Half Value Layer, with 3.5 mm Copper Extra Filtering (mm)
300	2.8	3.7
350	3.3	4.3
400	3.8	4.8
450	4.1	5.2
500	4.4	5.4
550	4.7	5.6
600	4.9	5.8
650	5.1	5.9

The tube wall filtering is estimated to be equivalent to 2.5 mm of copper. The third column is included so that comparison can be made with the constant potential half value layers given by A Bouwers and J H van der Tuuk (4), who used a tube having a 3 mm thick steel wall. Their data agree well with Column 3. Close comparison is not possible, however, since in both cases the copper equivalence of the initial tube wall filtering is merely estimated. Furthermore, their method of measuring voltage is not stated.

Copper is not as desirable as lead for comparing qualities by means of complete absorption curves. This is especially true when an open air chamber is used because the very thick filters scatter the beam so as to make almost impossible its proper collimation. Furthermore, there seem to be no available reliable monochromatic absorption coefficient data in the heavily filtered 600 kv ranges. For this reason it is not possible to compare accurately the relative filtering efficiencies of lead and copper in this region. However, rough extrapolations of available data give the advantage definitely to the lead, as might be expected.

#### VOLTAGE MEASUREMENTS

The 50 cm sphere gap was used as the voltage standard in making the absorption measurements. The calibration data used are found in Table II.

These data are included here because they are, as yet, unpublished data made available to us by the electrical measurements division of the Bureau of Standards. They consist of a provisional weighting

# A FLUOROSCOPE ATTACHMENT FOR CROSS-SECTION DRAWING AND LOCALIZATION, WITH AN ADAPTATION FOR RADIOGRAPHY

By MARTIN SZABADOS, M D , Brooklyn, N Y

**P**ALMIERI, in 1921, described the principle of an original method of obtaining a plastic model of the living heart by the aid of x-rays. Palmieri, who realized that the heart in silhouette is a record of the tangential rays, first obtained a series of films of the heart with the patient rotated at definite angles. Subsequently, these heart silhouettes were copied on cardboard and cut out. In the next stage of the procedure, he used a cutting wire, fastened to a fixed point representing the focus which followed the cardboard silhouettes in the order of their production. At the same time the wire cut off pieces of a plastic block, mounted on a turntable, to duplicate the various positions of the rotation of the patient. Thus was sculptured, for the first time, the model of a living organ.

It is very simple to visualize a fluoroscopic adaptation of Palmieri's principle. There must be two synchronized turntables, one for the rotation of the patient and one for the rotation of the plastic block. Such an apparatus has been designed by Lysholm, in 1926, and by Schatzky, in 1928.

For the purpose of cross-section drawing and localization, a similar apparatus has been developed. In such modifications, a writing system takes the place of the cutting system. Again the rotation of the record is synchronized with the rotation of the patient. The enveloping tangents can be produced by divergent rays exactly over the organ (Klason, 1929), the tangents can be obtained also by keeping the record in a stationary position overhead. Under such conditions the writing device moves with the fluoroscopic tube and screen which are made into a rigid system (Groedel, 1921).

The fluoroscopic adaptation of Palmieri's method utilized a horizontal plane for the production of the record. Cross-section drawings are obtained overhead, with the patient in a sitting position. The entire



Fig 1 Fluoroscope attachment for cross-section, adapted for divergent rays

apparatus occupies considerable space, and seems to be too elaborate when compared with its limited practical usefulness.

It would seem that the development of an attachment for one's own vertical fluoroscope would be more practical than the specially built fluoroscopes mentioned. The attachment herein described was developed by the writer and built in his office.

*I Attachment for the Method by Parallel Rays*—The attachment is built from maple wood, on a heavy base, 24 inches square, upon the center of which is mounted a horizontal circular turntable, 19 inches in diameter, to serve as a platform for the patient

previously, consist of 2.3 mm of lead, 0.5 mm of tin, and at least 0.5 mm of copper, and finally, 3 mm of celluloid

The expense of operation is relatively low in this installation. A convenient index of the expense for operation six days per week and about four hours per day is the monthly power bill. This averaged about \$50 at the rate of 1.75 cents per kilowatt hour. Other expenses cannot be easily stated, because in the past three years these have consisted mostly of developmental expenses and research.

*Acknowledgement*—The author wishes to express his appreciation for the energetic co-operation of Dr. R. L. Smith, the Clinic's founder and, until recently, its director. Gratitude is due also to Dr. L. S. Taylor, of the Bureau of Standards, and to Dr. G. Failla, of Memorial Hospital,

New York City, for advice and the loan of measuring instruments.

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tion necessary in marking points to be localized. Lines are recorded by pressing the ruler-supporting frame downward. Us-

ing of the fluoroscopic shutter. This indicates the direction of the central ray in orthodiagraphy.

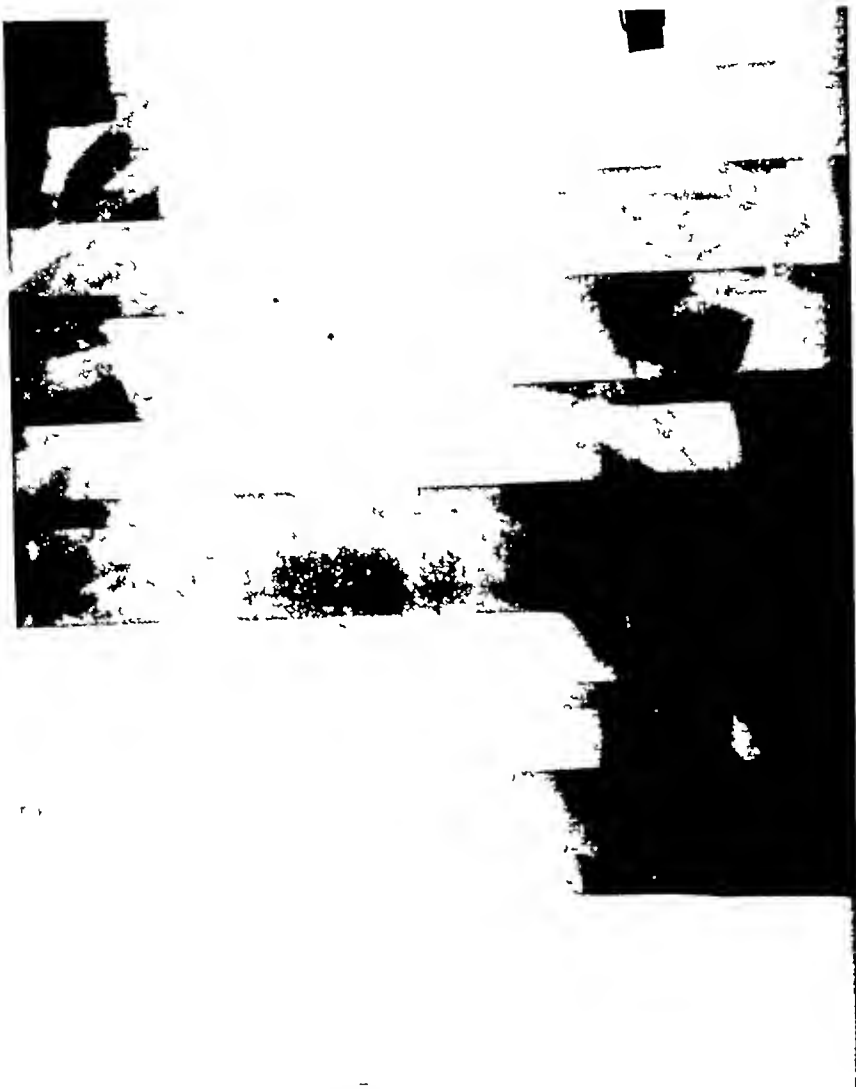


Fig 3 A segment of the rotated heart projected on strips of a film. An objective method of recording the tangential ray. Focus film distance is  $38\frac{1}{4}$  inches.

ing the edge of the ruler to aim at a desired point on the fluoroscopic screen would give inaccurate results, therefore, a narrow vertical slot is cut into the ruler just in front of the fluoroscopic screen. Into this slot a strip of fluorescent screen is placed. Records are made on white cardboard.

The position of the ruler is correct when the strip of fluorescent screen placed in it lights up in unison with a fluoroscopic light streak produced by a narrow vertical open-

The maneuver of rotating the patient and recording tangents is repeated until a shadow is enveloped by them or a desired point is localized.

The method of procedure is as follows. With the patient in a vertical position, standing on the horizontal turntable, supported by the vertical post, the horizontal shutter of the diaphragm is well narrowed down to a thin slit across the fluoroscopic screen at the desired level of the chest. A

as he stands erect for the examination. Six inches from the center a vertical post is built to support the standing patient in the

by a one-to-one wooden gear at the foot of the apparatus

The recording ruler reaches from t

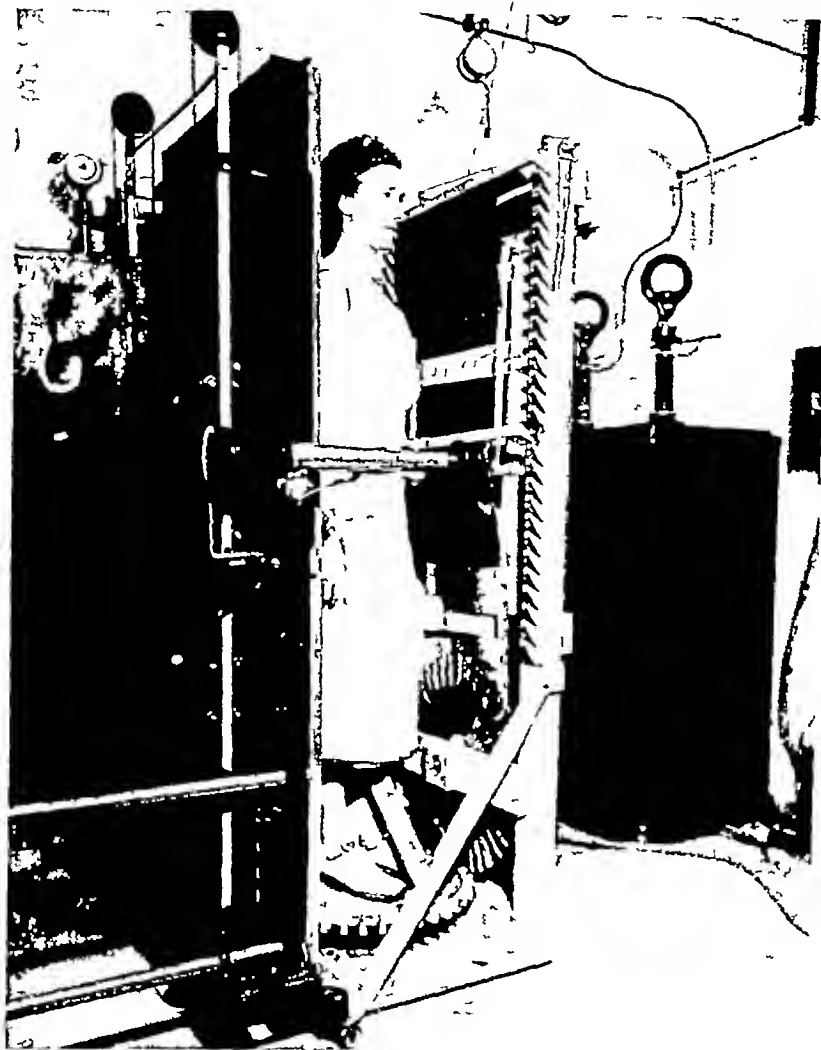


Fig 2 The attachment is mounted for radiography and placed in position for exposures

same position. The counterbalanced fluoroscopic screen and the recording system are mounted on a vertical frame attached to the solid base. A second turntable of similar construction is mounted perpendicular to the table which serves as a platform for the patient and as a mounting surface for the record.

The two turntables, one for the rotation of the patient and one for the rotation of the record, are geared up with each other

upper end of the apparatus to the record and is supported on a light frame, which moves in a vertical direction in grooves of the main stand. Two crude rubber bands, four fingers in width, at the top of the apparatus, provide for the elastic recoil of the ruler-supporting frame. A self-inking roller is fastened into the lower end of the ruler which serves as a recording device. The ruler may also be shifted from one side to the other by means of a brass rack, a mo-

fluoroscopic screen, therefore, a metal wire is suspended in the vertical midline of the fluoroscope, the shadow of which must co-

arm, the materialization of our tangential ray, is then used as a ruler and its direction is recorded on a white cardboard by a car-

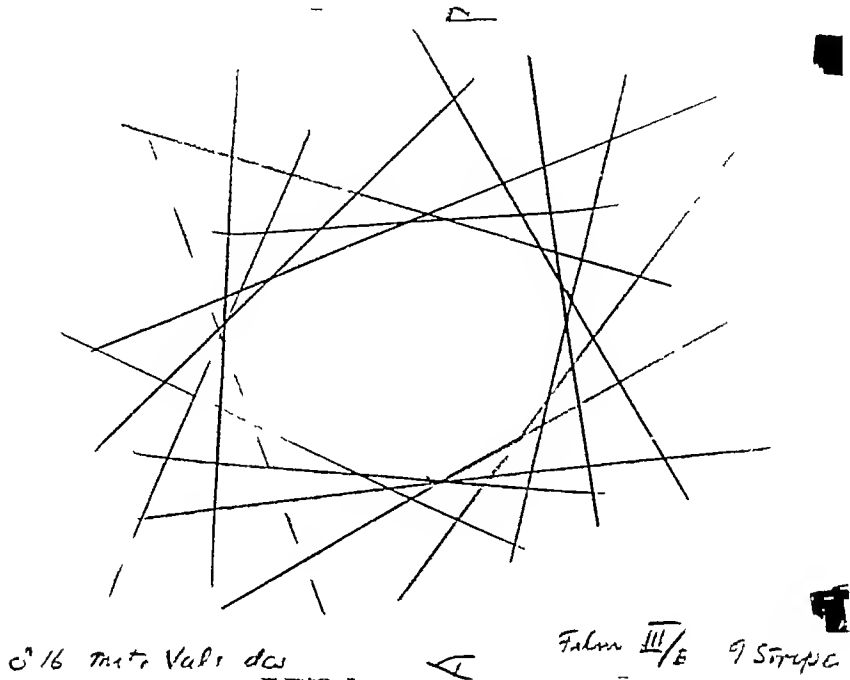


Fig 4 The tangential envelope of the heart is obtained on the basis of Figure 3. The tangents were transferred by the recording device seen in Figure 1. Drawing is true to size and shape. Patient male age 16 years, mitral insufficiency and stenosis.

incide with the vertical midline of the attachment. This midline is marked on the fluorescent screen by a black dermatograph. The focus of the x-ray tube is brought into the midplane by narrowing the vertical shutter. Once the central vertical streak of light coincides with the midline, the tube has to be clamped to prevent movement to either side. And after the focus is brought to the level where the cross-section is desired, vertical motion is prevented. The shutters are wide open and the tube is immobile.

The patient is then passed through a random rotation. The emergence of the tangential x-ray is marked by shifting the vertical arm on its rack. At the same time the arm, rotating around the model focus and joined with the vertical arm, will assume the position of the divergent tangent. This

penter's black crayon. Again we repeat the maneuver until the task is completed.

3 *Radiographic Variation of Method II*—For years we worked on the problem of a radiographic apparatus for cross-section drawing in original size. We thought that the solution lay on the line of teleroentgenography. Experiments along this line gave from 15 to 20 per cent enlargement and great distortion, which prevented us from thinking that the problem could be solved by divergent rays. When the fluoroscopic method for divergent tangents was tested, the long-sought solution of the problem occurred to us in a moment's time.

There was already a wooden rack for the hanging of lead sheets on both sides of the vertical stand, originating from experiments with teleroentgenograms. There



horizontal line, which is drawn by a black dermatograph on the midsection of the screen, is brought to overlap the narrow horizontal slit in the fluoroscopic light. At this moment the x-ray tube is clamped to prevent any vertical motion. After a brief orientation with open shutters, the vertical shutter is narrowed down to a thin slit. The tube is shifted horizontally until the vertical streak of light, the horizontal pencil line on the screen, and the border of the heart cross each other in one point. This is the moment when the central ray is tangential to the heart shadow at the level desired. Following this, the recording ruler and scribe are brought into position, by shifting the ruler on the horizontal rack until the fluorescent strip placed into the ruler lights up. This indicates that the center line of the ruler is in the direction of the central ray. The lever of the scribe is let down, pressing it against the white cardboard, the ruler is kept immobile by the left hand of the operator, while the right hand presses the frame in a downward direction. By this action a vertical line is drawn on the record. Before permitting the frame to recoil, the lever of the scribe is disengaged. Now we are ready to repeat the procedure by locating and recording a second tangent, and so forth. The patient is sent through a  $180^\circ$  rotation, sufficient to record ten to twelve well-placed tangents.

*II Modification of the Apparatus for Divergent X-rays*—The tangential envelope of divergent rays can be pictured best in our mind by seeing the imaginary set of tangents around the heart, from above. It is possible to produce a tangential envelope of original size above the heart on a turntable rotated concentrically with the patient's platform on the same axle (Klason).

With our apparatus we have to obtain the diagram of tangents on a turntable which is at rectangles with the turntable of the patient. A device must be provided for marking the emergence of the divergent ray and for recording its direction in the plane of the vertical stand. Besides, there are geometrical postulates, which are partly

self-evident and partly found out by experience. The center of the two turntables must be in the same vertical plane with the one crossing the focus. This plane must be at rectangles with the frontal plane of the vertical stand. Thus, the central ray is perpendicular to the screen. A fixed point is chosen in the midplane of the apparatus to serve as a duplicate focus, around which an arm is to rotate on a sector in front of the record. This arm is destined to duplicate the divergence of the tangential ray. The distance between the duplicate focus and the center of the record-holding turntable must be equal to the distance between the x-ray focus and the center of the patient's turntable. The length of the arm, supported by the fixed point, is equal to the focus-screen distance (or focus-film distance). The position of the tangential ray is located by means of a vertical arm, moving from side to side on a horizontal brass rack, as the ruler moved on our basic design. This arm extends in front of the screen downward toward the lower edge of the apparatus in order to take part in a mobile joint with the arm suspended from the duplicate focus. Thereby, a device is made for the transmission of the divergence of the tangential ray to the record. This arm, suspended from the fixed point, is used then as a ruler for the marking of the divergent tangents.

The longer vertical arm is made of two sections, joined by the means of a slot, permitting self-adjustment of the length. A protruding sighting device is on the reverse aspect of the perpendicular arm, toward the screen. The sliding frame of the previous apparatus, which carried the ruler and the inked scribe, is now solidly fastened to the vertical frame. The scribe is removed. The remaining ruler was altered and became the vertical arm with its two sections. The model focus is also supported on a crosspiece of this frame.

The method of procedure is as follows. It is very important with this method to center the x-ray tube correctly. Deviations from the central ray cause most serious displacements of the tangents. The central ray must be perpendicular to the

the patient to stand immobile, both during the fluoroscopic and the radiographic phase. With the radiographic method, at full daylight, the patient is greatly aided in maintaining the initial position by his eyesight, which plays an important rôle in maintaining body equilibrium. The method can be completed by a technician.

Palmieri's original method was modified by several authors. These modifications did not alter Palmieri's principle, and they differ mainly in the method of synchronization of the rotation of the patient and of the record. Groedel synchronized the scriber with the deviations of the central ray on a sector around the patient, and eliminated the turntable for the rotation of the record. Klason, by rotating the record overhead, concentrically with the patient's turntable, could use divergent rays and obtain a diagram of original size. Granted the excellence of these two methods, a good radiographic procedure was not devised.

Our apparatus differs from others mainly in the method of synchronization. But, as

with others, the introduction of a new way of synchronization resulted in certain advantages. Working with the patient in the upright position permitted the gearing up of the two turntables with each other. This resulted in reducing the overhead equipment, permitting the use of ordinary fluoroscopic settings, and making the record visible during its production. Finally, it gave opportunity for the development of a radiographic method. This, if a good radiogram is granted, is the only method which permits a check on the accuracy of the record, without recalling the patient.

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also was a niche for a 14 by 17 in cassette, on the back side of the frame carrying the fluorescent screen. The apparatus thus equipped was placed in position at the vertical fluoroscope, which was destined now to act as a radiographic apparatus. A plaster disc, imitating a heart cross-section, was fastened upon a lamp stand and placed on the horizontal turntable. Through the opening of an adjustable horizontal lead shutter, which was hung at the desired level, a 14 by 17 in film was exposed, strip by strip, as the cassette was lowered two inches at a time, and the platform with the model was rotated before each exposure, by a definite angle. A  $180^\circ$  rotation was completed. The film, developed and dried, was placed between two glass plates the same size as the cassette and then replaced upon the stand in the niche in the very same position in which the exposures were made. The individual strips of the film had been considered as if they were fluoroscopic images, superseding each other during rotation. The tangents were transferred, as described in the procedure for divergent rays, the record having to be rotated with known angles before each transfer.

We found that an error of  $\frac{1}{4}$  of an inch is inherent in the apparatus. Apart from this, one is delighted with the precision of the diagram by the radiographic method.

Localization experiments with plaster discs, representing the heart and spine, and with a steel ball to be localized were also done, and with good results.

The classical objective is the cross-sectional drawing of the heart. We chose from among the patients a frail boy with double mitral disease, of whom we took three series of strips of the rotated heart, resting him a day between films. We replaced the first film between two glass plates in the niche where the exposures were made and contemplated the first film with trepidation. There were six strips exposed resulting in ten tangents. The subsequent films with nine strips gave twelve tangents available for transfer. If the distribution of the tangents is favorable,

twelve lines will result in a beautiful diagram.

In the average patient, the heart shadow cannot be sufficiently defined in the region of absolute heart dullness. Our frail patient was an exception.

We again mention the geometrical precision by which the tangents follow each other. The appearance of the cross-sectional drawing prepared by fluoroscopy is somewhat less orderly, although the drawings obtained by the two methods check very well from a practical viewpoint.

Finally we wish to remark that, with patients of average weight, provision must be made for film-changing, or, better yet, a roll film should be used. This will permit the exposure of a larger number of strips, the roll film would also eliminate the bulky shutter and the lead sheets, and would reduce the film-chest distance. To be able to rotate the patient we required considerable space, which resulted in about eight inches film-chest distance. This is necessary, for we could not alter the basic design of the apparatus, which had already been rebuilt several times.

#### DISCUSSION

A fluoroscopic attachment designed for cross-sectional drawing, by either the parallel or divergent rays, may become a useful adjunct to our x-ray apparatus.

Working with parallel rays requires more manipulation of the fluoroscope, it is a longer procedure and more strenuous for the patient. This method was presented, therefore, more for didactic reasons. The procedure with divergent rays puts very little strain on the patient, especially if an assistant aids in recording.

There is a subjective factor with these fluoroscopic methods, dependent upon the operator. The author worked out a correct radiographic method, which provides for an objective marking of the tangents, and, thereby, the stage of transferring of the tangents becomes a clean-cut draftsman's procedure.

The geometrical exactness of the cross-section diagram depends on the ability of

TABLE I —X-RAY INTENSITIES OF DIFFERENT GENERATORS

200 kv Generators						
Generator	Ma	S T D (cm )	Filters (mm )	Half Value Layers (mm of Cu)	Roentgens per Minute	
					Measured	Per ma at 70 cm
A	30	70	1 Cu + 2.25 Al	1.25	17.6	587
B	20	70	1 Cu + 7 Al	1.40	11.8	589
C	30	50	1 Cu + 1 Al	1.25	32.5	587
D	30	70	1 Cu + 1 Al	1.23	20.9	696
E	8	70	1 Cu + 3 Al	1.50	7.9	1.48

100 kv Generators No Filter				
Generator	Ma	S T D (cm )	Roentgens per Minute	
			Measured	Per ma at 12 in
1	8	16	87.0	19.2
2	2.5	10	98.5	27.5
3	5	10	237	33.2
4	4	16	59.4	26.2
5	5	12	61.9	12.4
6	4	12	86.4	21.6
7	8	12	163	20.4
8	4	12	90	22.5

100 kv Generators 1 mm Al				
1	8	10	97.0	8.3
2	2.5	10	40.3	11.2
3	5	10	83.0	11.5
4	4	16	20.1	8.9
7	8	10	101.4	8.8
8	4	12	37.6	9.5

culated values are sufficiently accurate to demonstrate close agreement in output of the 200 kv group in contrast to the lower potential group. The output of machine E was expected to rise above the others for the "constant" potential circuits have been shown to do so elsewhere. The maximum of unfiltered radiation is nearly double the minimum radiation intensity of generators in the 100 kv group. The ratio is less if the rays are filtered by 1 mm. of aluminum.

There are several possible causes for the non-uniform radiation intensities of machines which apparently are operated at

the same peak voltage and average currents, and which use the same type of tubes, electrical circuit, and filters. Probably most of the difference observed in practice can be attributed to the generators and auxiliary equipment and not to the tubes themselves. Taylor has shown that tubes of the same make and type give practically the same output on any one generator. Aside from misalignment of target and ports, improper shielding of stem radiation, and other adjustments of this nature which may be corrected in the treatment room, there are other less controllable factors which in-

# RADIATION INTENSITIES OF X-RAY GENERATORS

SOME OBSERVATIONS DURING THE CALIBRATION OF MACHINES FOR THERAPY PURPOSES

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THE intensities of several x-ray generators have been measured during the past two years preceding my transfer, in January, to a temporary stay in China. The measurements were a part of the services made available to hospitals and clinics in some of the north-central States. The results from each generator were obtained for clinical use, therefore, a comparison of them was necessarily limited to a few instances in which approximately similar conditions existed. The point to be stressed is that the results are characteristic of the machines exactly as they are used clinically and not as they might have been prepared for exact experimental tests. Five deep therapy (200 kv) and eight superficial therapy (100 kv) machines are included in the comparisons. The measurements show significant discrepancies of intensity between like machines in the superficial group in contrast to the more uniform output of the higher potential group. Perhaps this can be expected. In recent years a great amount of time and energy has been expended in the development and manufacture of the higher voltage generators, while less attention has been given to the perfection of 100 kv machines. In many institutions the low voltage generators are assembled from discarded parts of old machines. From the economical standpoint this practice may be commendable, but therapeutically it should not be encouraged. Since there is a tendency among certain institutions to pay less attention to their low voltage x-ray intensities, the fact should be emphasized that the 100 kv machines are erratic in their x-ray production, consequently, these machines need frequent recalibrations.

The x-ray intensities were measured in free air by means of a thimble ionization chamber. The sensitivity of the dosimeter

was kept approximately constant by frequent checking and adjustments in a standardization laboratory. Immediately preceding the measurements, the peak voltage of each machine was determined by the sphere-gap method. Appropriate temperature and atmospheric pressure corrections were applied to the sphere-gap settings and to the r-meter records. Tubes and insulators were cleaned beforehand. Insofar as possible intensities were measured with identical filters, tube currents, and target-meter distances, still these factors had to be selected to meet the need of each individual clinic. For this reason only three groups of measurements are comparable. They are given in Tables I and II.

The first four generators in the 200 kv group used mechanically rectified currents and water-cooled Coolidge x-ray tubes (Table I). The latter were housed in various kinds of lead protection drums. The fifth 200 kv generator, which is added merely for comparison, is a full wave, valve tube condenser, "constant" potential generator. An oil-immersed tube of the Westinghouse 200 kv type is used with this circuit. All of the 100 kv generators except No. 5 were mechanically rectified, No. 5 used half-wave, valve tube rectified current. Air-cooled, broad focus, universal type Coolidge tubes were used without exception in these generators.

For purposes of comparison, the measured intensities in roentgens (r) per minute were reduced by calculation to identical conditions except for small differences in filter thicknesses in a few cases. The inverse square law of intensities and direct proportionality of tube currents and intensities were assumed. The inverse square law is not precisely applicable to short distances and broad focal spots, but the cal-

## A ROENTGENOLOGIC STUDY OF 115 CASES OF APPENDECTOMY FOR SO-CALLED CHRONIC APPENDICITIS

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**D**URING the past few years we have encountered a large number of adult patients on whom an appendectomy had been performed for so-called chronic appendicitis, without relief of their symptoms. The histories in these cases were so striking that they left considerable doubt in one's mind as to the real necessity for the operative procedure. Although it is well known that this situation exists, it is not usually accorded the serious consideration it deserves. However, it seems apparent from our study that the indiscriminate removal of the so-called appendices of the chronic type has become much more prevalent than has hitherto been recorded. The unwarranted removal of the appendix for vague abdominal symptoms is of such common occurrence that it should be discouraged by both the internist and surgeon. The roentgenologist is not altogether blameless in this regard, for too often a roentgenologic diagnosis of chronic appendicitis is made and the patient is rushed to the surgeon, who removes the appendix without further considering the possibility of other conditions which may be responsible for the gastro-intestinal disturbance. Unfortunately, the surgeon is not aware of the large number of cases—their numbers are increasing—that return unrelieved to the internist or gastro-enterologist. Many patients, especially those of a neurotic tendency, even find themselves in a worse state, and are much more difficult to control than if they had not been operated upon. Hunner (1) adequately expresses the opinion of many observers on this subject, stating "The formula to operate first, then investigate, is a formula in which there is absolutely no defense when dealing with so called chronic appendicitis, a diagnosis which has led to more useless opera-

tions than any other in the category of abdominal surgery."

An attempt will be made in this presentation to demonstrate that in a vast number of cases a thorough roentgenologic investigation of the digestive and urinary tracts will undoubtedly materially reduce the number of patients operated upon for so-called chronic appendicitis. In a large percentage of instances the true nature of the gastro-intestinal or other abdominal conditions will be correctly diagnosed by means of this procedure. Our experience has shown that the diagnosis of chronic appendicitis is often very difficult, and it behooves one to be extremely cautious in arriving at such a diagnosis without a painstaking examination. It is far better to make innumerable unnecessary investigations than to have a patient subjected to a useless and often harmful operation.

The roentgen method of diagnosis of chronic appendicitis will not be considered in this communication. It is not to be inferred, however, that the x-ray diagnosis can be arrived at without difficulty nor is it a method of choice in the examination. As a direct means of establishing a diagnosis, the x-ray offers little aid, it is often misleading and not infrequently leads to an erroneous decision. Its greatest usefulness, however, is in the differential diagnosis, eliminating the more common gastro-intestinal and urinary conditions which closely mimic appendiceal disease. The main reason for focussing attention upon this subject at this time is to again emphasize the fact that a properly and routinely performed roentgen investigation will in many instances prevent many of the diagnostic errors which we now so commonly encounter. From a study of our cases, there seems no doubt but that diag-

TABLE II — REPEATED CALIBRATION OF SAME GENERATORS

Generator	Roentgens per Minute	
	1934	1935
A	17.6	15.4 15.3 15.4
B	11.8	15.9
C	32.5	33.8
1, 0 filter		74.9 67.9 87.0
1, 1 mm AL	90.5 97.0	104.5 90.2
2	98.5	121
3	237	250

fluence the x-ray output. The wave form of the applied voltage, which depends to a large extent upon the power drawn from the generator, determines the quantity as well as the quality of the radiation. The complete descriptions of dosage should include some characterizing factor, thus, the x-ray beam's absorption curve for copper, or its half value layer is recommended.

Another cause for the observed differences in output may be errors in the milliammeters and in voltage determinations. Milliammeters in circuits assembled from old spare parts or in circuits of poor electrostatic shielding are subject to inaccuracies. The checking of milliammeters should be a routine part of the work. Voltages determined by means of sphere gaps may include unavoidable errors in practice. For example, at the time of calibrating generator D, an accurate value of the barometric pressure could not be obtained since there were no reliable barometers in the small town in which the hospital was located. Therefore, the high roentgen output of this unit may have been caused

by a voltage setting actually greater than 200 kv.

Radiologists who do not possess or have frequent access to dosage meters invariably ask how often their x-ray units should be calibrated. The answer depends on the use and stability of each particular generator. Undoubtedly some generators require more frequent calibrations than others. The measurements have not been extensive enough to allow one to draw fixed conclusions or to set a minimum number per year, still a few repeated tests present certain indications (Table II). An interval of at least three months elapsed between the repeated tests. New x-ray tubes were installed between the 1934 and the 1935 tests of generators A and B. In all other instances the same tubes were in use. Thus, constancy of x-ray output may be expected from 200 kv generators as long as the same tube is used. The installation of a new tube may result in appreciable change in intensities, therefore, recalibrations are suggested immediately. The 100 kv generators are not so constant, they should be recalibrated frequently.

The results show clearly that to express x-ray dosage in milliamperes-minutes with certain peak voltages is not sufficient. Doses described exactly alike in these terms may differ in total roentgens. It must be emphasized that low voltage generators for therapy purposes are likely to be more erratic in x-ray output than the 200 kv generators. Dosage limits between good results and skin injuries are as narrow for superficial therapy as for deep therapy, particularly protracted deep therapy, therefore, standardization and recalibration of both types of generators are equally important.

It will be noted from this table that the greatest number of cases occurred between the ages of 20 and 50 years. There were 64 males and 51 females in this series. Routine roentgenologic examinations were made in each case.

It is noteworthy to observe the large number of cases which revealed some gastro-intestinal pathology accounting for the true nature of the disease. The following table represents the x-ray findings in 115 cases of post-operative appendectomies.

Gastric ulcer	4 cases
Gastric carcinoma	1 case
Gastric retention	13 cases
Pyloric ulcer	4 cases
Spastic pylorus	54 cases
Duodenal ulcer	34 cases
Irritable duodenal cap	14 cases
Duodenitis	3 cases
Duodenal stasis	1 case
Duodenal adhesions	2 cases
Duodenal diverticula	1 case
Colitis (irritable, spastic colon)	43 cases
Colonic stasis	8 cases
Redundant colon	1 case
Diverticulosis of colon	1 case
Cholecystitis	17 cases
Non-filling of gall bladder	2 cases
Cholecystic adhesions	2 cases
Gallstones	9 cases
Kidney stones	2 cases
Ureteral stones	4 cases
Ptosed right kidney	1 case
Calcification of abdominal aorta	1 case

In Bettmann's series of 170 cases, the most frequent affections noted were as follows:

Gastric and duodenal ulcer	20 cases
Disease of the gall bladder	16 cases
Colitis	12 cases
Genito-urinary cases	9 cases

Friedenwald and Morrison (10), in 1931, reported 100 cases of so-called appendicitis in which appendectomies had been performed with unsuccessful results. Their clinical diagnoses were as follows:

Peptic ulcer	24 cases
Cholecystitis or cholelithiasis	21 cases
Renal and ureteral disease	4 cases
Pelvic disease	2 cases
Colitis	11 cases
Carcinoma of cecum	2 cases
Neuralgia of abdominal wall	14 cases
Tuberculosis of cecum	2 cases
Abdominal adhesions	19 cases
Hernia	2 cases

From our roentgenologic findings and from reports of other observers, the most striking and the more frequent findings

were those affections which were readily discernible by means of the roentgen ray.

The percentage of the more common findings in three series of cases are as follows:

Author	Peptic Ulcer (Gastric and Duodenal)	Gall-bladder Pathology	Genito-urinary Pathology
Bettmann, 170 cases	11 7%	9 4%	5 3%
Friedenwald and Morrison, 100 cases	24 0%	21 0%	4 0%
Feldman, 115 cases	36 5%	26 0%	6 0%

Gastric disease was found in eight instances, these included peptic ulcer in seven and carcinoma in one. Gastric retention of six hours or longer was noted in 13 instances.

Duodenal ulcer occurred in the greatest number of cases in all reported studies on this subject. This series yielded 54 cases which revealed duodenal abnormalities, 34 of which showed definite evidence of chronic duodenal ulceration. It might be emphasized here that, in a few cases which were x-rayed prior to operation, the presence of ulceration had been entirely overlooked. This was no doubt due to faulty roentgen technic, as the defect in these cases was detected only under palpatory manipulation and pressure. The co-existence of duodenal ulcer and chronic appendicitis has been pointed out by many observers. In this series of cases there was no question of a double lesion whatsoever but rather a mistaken diagnosis, as judged by the clinical and roentgenologic studies.

Other duodenal abnormalities have been found, such as irritable duodenal bulb, duodenal adhesions, duodenitis, duodenal stasis, and duodenal diverticula. It is interesting to note that Shattuck and Imboden (11), in a report of 46 cases of chronic intermittent duodenal obstruction, state that more than half of the patients had had their appendix removed when first seen and in none had the symptoms improved following its removal. Niles (12) likewise called attention to the frequent removal of the appendix in patients with duodenal fixation. In his 39 cases, 28 had had their appendix removed.



nostic misinterpretations are especially responsible for this condition

According to Maes (2), published figures would indicate that the patient has only a 15 to 50 per cent chance of receiving benefit from the operation for chronic appendicitis. Evans (3) points out that the percentage of patients not relieved by appendectomy is considerable. White (4) also calls attention to the fact that fully one-half of the patients in whom the appendix had been removed for chronic disease, return without relief of symptoms. Lichty (5) likewise reports 40 per cent of failures, while Smith (6) is of the opinion that simple appendectomy will cure less than 50 per cent of cases. Gibson (7), in 1920, reviewed 555 cases of appendectomy and recorded a large percentage of failures attributed to inadequate study. Bettmann (8), in 1924, collected 300 cases in which appendectomy had been performed without relief. Of these, he found that 35 patients (11.6 per cent) had been made definitely worse by the operation. He further pointed out, in 1928, that the results were disappointing in 40 per cent of cases. Scholz (9) considers that there must be something wrong with the method of diagnosis of chronic appendicitis if 40 per cent of appendectomies are performed unnecessarily.

The material selected for the study of this subject comprises a group of 115 consecutive cases seen in a consultation gastro-intestinal roentgenologic practice. This series of cases comprises a group collected from various scattered sources and localities and were not the cases of any particular surgeon or clinic. Following a study of the history of each case, it was disclosed that in a majority of instances no x-ray study had been made prior to operation. Our records show that a complete gastro-intestinal x-ray investigation was made in but 13 instances, and in a small number of additional cases only a fluoroscopic examination of the gastro-intestinal tract had been made. More than 80 per cent of our cases revealed evidence of an inadequate pre-operative study. As far as could be ascertained, in not a single instance was a com-

plete combined gastro-intestinal, gall bladder visualization test, and genito-urinary tract investigation made prior to operation. Our records further show that single examinations of the gall bladder or genito-urinary tract alone were made in but few instances. None of the cases have had any special x-ray investigations, such as of the colon, or pyelographic studies before operation. These studies undoubtedly indicate the inadequacy and lack of roentgen studies in the pre-operative diagnosis. Bettmann had found that 60 per cent of patients in whom an unsuccessful appendectomy had been performed had received no adequate pre-operative study.

In our opinion it would seem advisable in every instance of suspected chronic appendicitis to institute a thoroughly meticulous painstaking x-ray investigation. This must include not only the gastro-intestinal tract, but also examination of the gall bladder, colon, and genito-urinary tract. Following these examinations, one may then be more positive that the percentage of diagnostic errors and subsequent operative failures will be appreciably reduced. Inadequate pre-operative study for chronic appendicitis is further to be deprecated, inasmuch as the patient is entitled to every possible diagnostic measure, in order to definitely determine the cause of the gastro-intestinal disturbance. Since the roentgenologic procedures offer a method which will greatly aid in eliminating a large number of affections which more commonly produce gastro-intestinal symptoms, its use should be insisted upon and form a routine in all well-managed hospitals before operative procedure is undertaken.

The following table represents the ages in our series of 115 cases arranged according to decades.

17 to 20 years	6 cases
20 to 30 years	23 cases
30 to 40 years	39 cases
40 to 50 years	29 cases
50 to 60 years	15 cases
60 to 70 years	3 cases
	<hr/> 115 cases

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In 53 cases (46 per cent) some disturbance of the colon was found. Colonic enemas were given in 15 cases, which had symptoms of a more severe colonic condition. In 43 cases varying degrees of spastic and irritable states were encountered. Colonic stasis was observed in 8 instances or approximately 7 per cent.

Gall-bladder pathology was noted in 30 instances. A gall-bladder visualization test was made in 52 cases or approximately 45 per cent of this series. In 22 cases it was observed to be normal and in 30 abnormal. The large number of cases showing evidence of cholecystitis is striking, there was little or no contraction of the gall bladder following a fat meal. There were 17 cases of cholecystitis, two cholecystic adhesions, nine gallstones, and in two non-filling of the gall bladder. Judging from the records obtained from the 115 cases, a gall-bladder visualization test was made in but few instances prior to operation.

A scout film of the abdomen, including a view of the genito-urinary tract, was made 28 times. In a few instances pyelographic studies were also carried out. Of the 28 cases in which a plain film was made of the genito-urinary tract, kidney stones were observed in two, ureteral stones in four, and in one a ptosed right kidney. It is suggested from a review of the histories that many more instances of genito-urinary affections might have been encountered had it been possible to make routine cystoscopic and pyelographic studies. Most urologists are quite familiar with the prevalence of appendectomy cases in their practice. The percentage of patients with renal and ureteral disorders on whom the appendix had been removed varies considerably, the percentage ranging from 10 to 40 per cent. O'Neil (13), in 1921, pointed out that about 25 per cent of the patients at the Massachusetts General Hospital who had ureteral calculi, had had operations for appendicitis or some other intra-abdominal condition before a correct diagnosis was made. Turlington (14), in a study of 115 ureteral stricture cases, found that 40 per cent of the cases presented abdominal

scars, many of them had had two or more operations. Hunner (1), in a report of 100 cases of ureteral stricture, found that 71 had been operated upon before undergoing treatment, 30 of which were diagnosed as appendicitis.

#### CONCLUSIONS

(1) A thorough painstaking roentgen examination of the gastro-intestinal tract, gall bladder, colon and genito-urinary tract, including cystoscopic and pyelographic studies when indicated, is necessary to carry out in every case of suspected chronic appendicitis.

(2) In a study of 115 cases of so-called chronic appendicitis, following removal of the appendix, the roentgen examination revealed in a large proportion of instances pathologic findings other than the appendix, which accounted for the gastro-intestinal disturbance.

(3) In the series of 115 cases, there were 36.5 per cent peptic ulcers, 26 per cent gall-bladder pathology, and 6 per cent involved the genito-urinary tract.

(4) From this study, one is greatly impressed by so large a group of cases which were inadequately examined from a roentgenologic standpoint before operative procedures were instituted.

(5) The differential diagnosis of chronic appendicitis is almost impossible without the aid of roentgenologic studies, by which means a large number of conditions producing gastro-intestinal symptoms which closely mimic appendiceal disease may be ruled out.

(6) In no instance should operative measures be undertaken for chronic appendicitis until all other conditions have been thoroughly eliminated. The roentgen method of investigation is of the greatest importance as an aid in the ultimate diagnosis.

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# LATERAL ROENTGENOGRAPHY OF THE FEMORAL NECK<sup>1</sup>

By ALBERT B FERGUSON, M D, Director of Roentgenology, and FREDERICK L LIEBOLT, M D, Annie C Kane Fellow, New York City

From the New York Orthopedic Dispensary and Hospital

UNTIL recent years orthopedic surgeons have been content to view the neck of the femur in the anteropos-

been taken as a matter of fact, and little work along this line has been attempted

In 1932, Clayton Johnson<sup>2</sup> described an

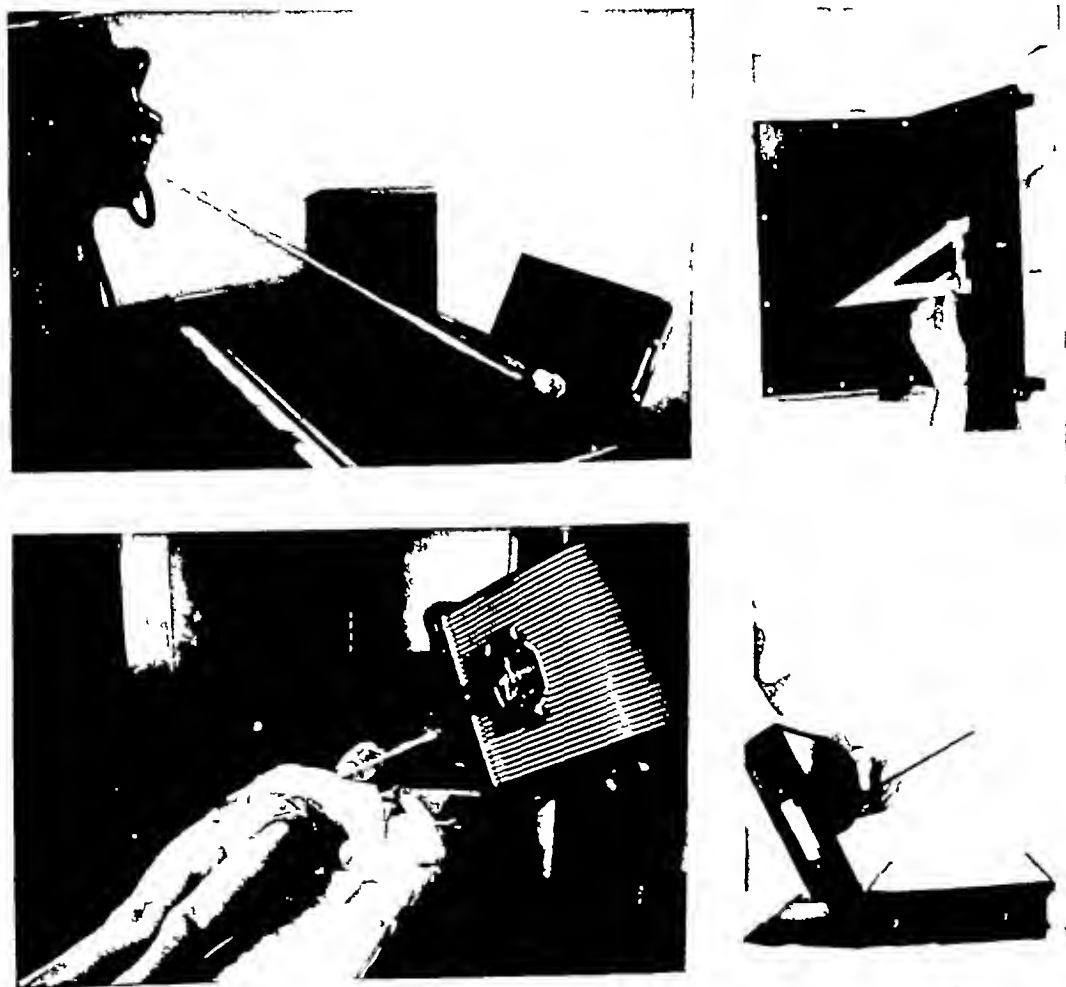


Fig 1 (upper right) Cassette holder viewed from above Triangle indicates a line 25 degrees from transverse  
(lower right) Cassette holder viewed from end Triangle indicates line 25 degrees from horizontal  
(upper left) Femur on cassette holder Central ray is in the plane of the femoral neck  
(lower left) Patient on cassette holder

terior or oblique planes roentgenographically Inability to produce satisfactory lateral roentgenograms of this part has

accurate method whereby the femoral neck might be viewed laterally for judging displacement in fracture of the neck With

<sup>1</sup> Read before the Section on Orthopedic Surgery of the American Medical Association Kansas City Mo May 13 1936

<sup>2</sup> Johnson C R A New Method for Roentgenographic Examination of the Upper End of the Femur Jour Bone and Joint Surg 1932 14, 859-866

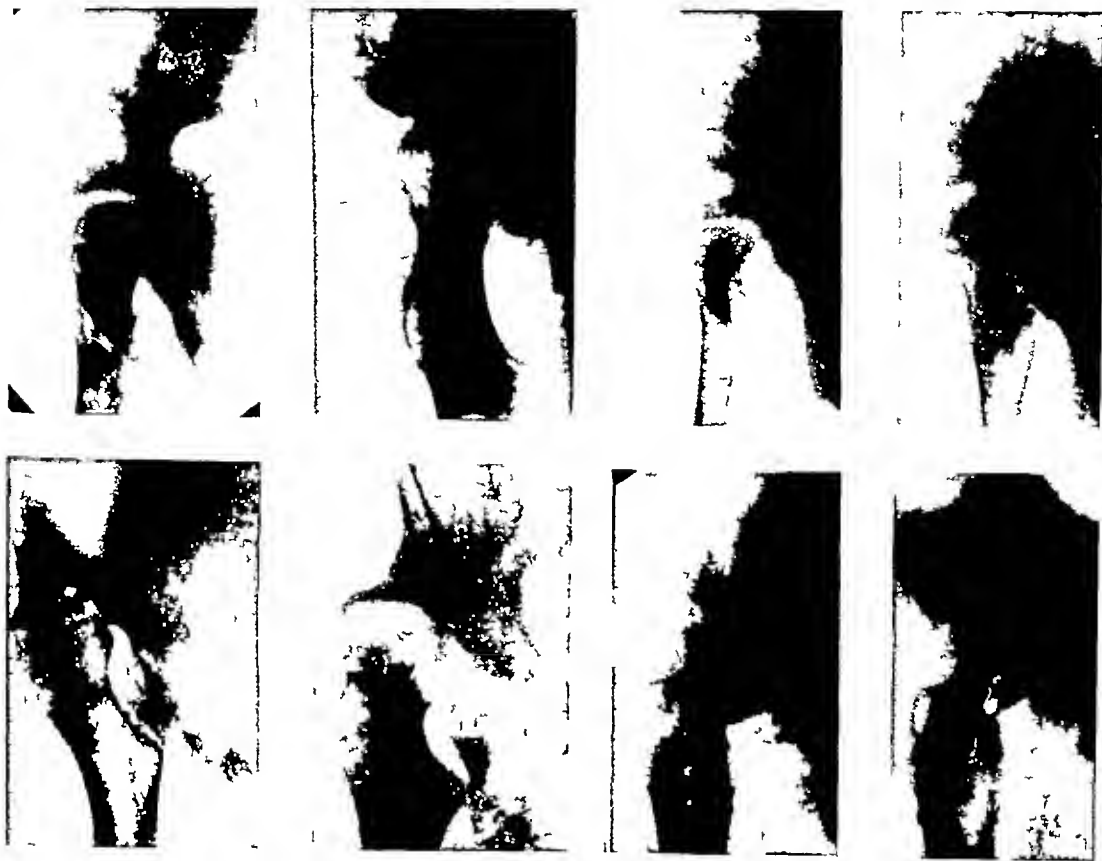


Fig 2

Fig 3

Fig 2 (*upper left*) Normal The femoral neck is projected in line with the shaft The acetabulum is well shown

(*upper right*) Coxa valga The femoral neck is long in proportion to the size of the head and trochanters (*lower right*) Anteroposterior view of congenital dislocation of the hip after shelf operation The lateral view of the same hip is shown at the left Anteversion is demonstrated by the deviation of the neck anterior to the line of the shaft Note that the shelf extends down over the head anteriorly

Fig 3 (*upper left*) Coxa plana is reduced—unstable congenital dislocation (*upper right*) Shallow femoral head and irregular epiphyseal line due to coxa plana Note that the head is slightly displaced posteriorly on the neck

(*lower left*) Epiphysiolysis The head is completely displaced to the posterior aspect of the neck (*lower right*) The same hip after correction of displacement and insertion of nail This view obtained through plaster spica

the patient in a supine position, he placed a film parallel to the long axis of the femoral shaft and inclined from the horizontal 65 degrees. He then directed the central rays across the patient at an angle 25 degrees below horizontal and across the thigh toward the femoral neck at an angle 25 degrees from the transverse plane of the femoral shaft (Fig 1).

The projection thus obtained was in the plane of anteversion of the femoral neck, commonly called the lateral view, and was undistorted as to relative length of neck to head or shaft. Such a view is readily ob-

tained, can be applied to examination of the femoral head and hip as well as the femoral neck, and is not subject to distortion by curvature of the film.

For these reasons the authors have selected this method for use in the investigation of conditions other than fracture, and have elaborated the technic to include a cassette holder to simplify positioning, a Lysholm grid to improve the radiograph, and an exposure technic to insure adequate exposure.

The cassette holder, which we obtained commercially although it can readily be

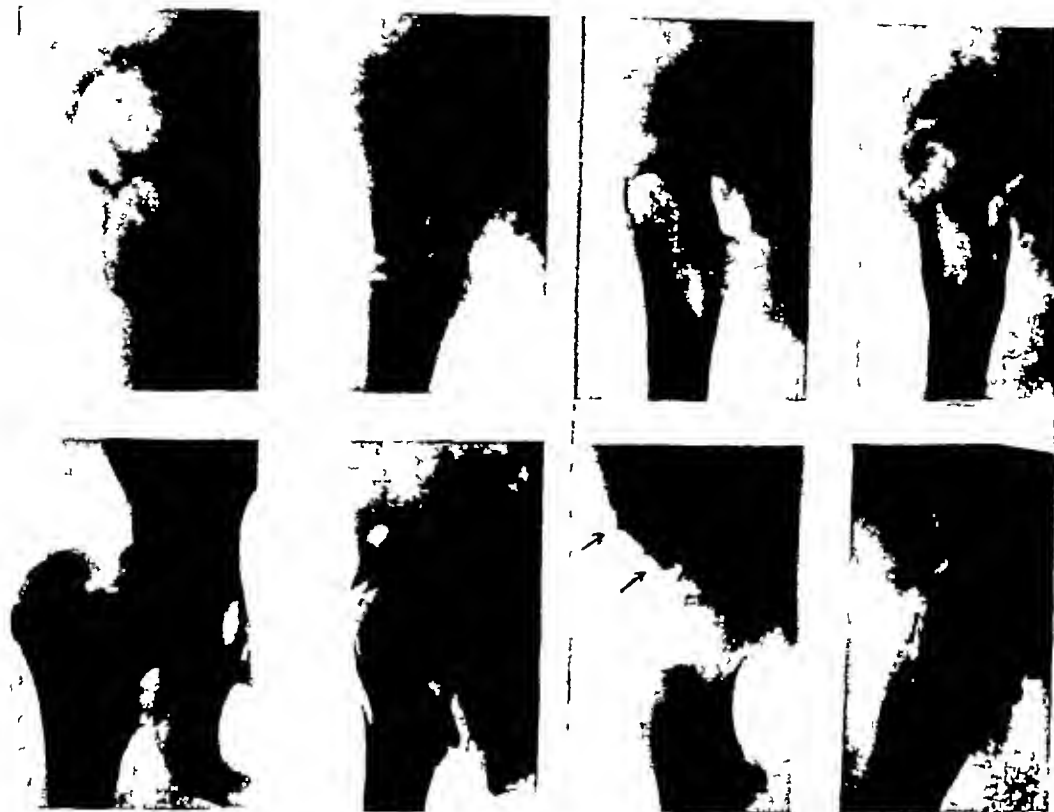


Fig 4

Fig 5

Fig 4 (upper left) Residual of suppurative arthritis. Note the long spur curving anteriorly from the acetabulum down to the femoral neck.

(upper right) Subtrochanteric osteotomy after fusion of hip for tuberculosis. Note solidity of fusion and alignment of fragments. This view was obtained through plaster spica.

(lower left) Tuberculosis of ilium, anteroposterior view. Cavity near lateral margin of the acetabulum can hardly be detected. The lateral view of this hip is shown at the lower right. The cavity is clearly demonstrated in the anterior portion of the roof of the acetabulum.

Fig 5 (upper left) Reconstruction operation for osteo-arthritis. Note the narrow anteroposterior diameter of the remainder of the femoral neck.

(upper right) Osteo-arthritis. Note the irregular thickening of the femoral head and neck anteriorly.

(lower left) Apophysis of the ilium in two parts. This was not shown so well in the anteroposterior view.

(lower right) Flexion deformity after reduction of displacement in epiphyseolysis. Note that the femoral shadow is not projected vertically but deviates anteriorly in flexion.

constructed, consists of a base on which the patient rests and a side piece tilted 65 degrees from the horizontal. These are of veneer wood, transparent to x-ray, and are held by a metal frame in which two cross bars form a space behind the side piece in which the 8 X 10 film cassette and Lysholm grid may be placed readily and held at the correct angle. A metal triangle with a long wooden pointer indicates the proper centering point for the roentgen tube 25 degrees distal to the transverse plane and 25 degrees inclined from the horizontal.

The base of the holder is slipped under

the patient's hip, its side piece against the thigh and parallel to the axis of the femoral shaft with the femur in neutral rotation, and the proper positioning is obtained readily and without disturbance by means of the centering triangle.

The Lysholm grid, placed between the cassette and cassette holder, is a necessary adjunct in that it greatly diminishes secondary radiation and yields a much more satisfactory radiograph.

To determine exposure, measure the transverse diameter of the patient from skin to skin, or plaster surface if a spica

has been applied, at the level of the greater trochanters. At 36 inches target-film distance, with fast films, screens, and developer, and using 80 milliamperere-seconds of current, 3 kilovolts per inch of diameter, plus 30 kilovolts, is adequate exposure. Either the 30 kilovolts added, or the basic milliamperage, may be increased or decreased to adjust the scale to slower or faster equipment. Also, if the thigh is atrophied, subtract from 2 to 4 kilovolts, if swollen, add from 2 to 8 kilovolts.

The advantages of this simple technic are

1. There is no difficulty in localizing the femoral head and neck on the film.

2. Distortion of the image is minimal.

3. A normal projection is accurately established, and deviations from the normal alignment of the neck, as in coxa valga, coxa vara, and anteversion, are revealed as variations from this normal projection.

4. The difficulties inherent in the use of a curved cassette are avoided.

5. The examination may be made at the bedside without seriously disturbing immobilizing appliances.

6. There is no discomfort for the patient.

The method is of value in determining

- (a) Alignment of the parts of the femur in fracture, subtrochanteric osteotomy, slipped epiphysis, anteversion, coxa vara, and coxa valga.

- (b) The site, extent, and character of osseous changes in the femoral neck or head, acetabulum, or anterior portion of the ilium, in osteomyelitis, tuberculosis, coxa plana, osteo-arthritis and rheumatoid arthritis, congenital dislocation of the hip, etc.

- (c) The condition of the apophysis at the margin of the acetabulum, swelling or abscesses anteriorly at the hip, state of fusion or relation of parts after fusion operation or shelf stabilization.

- (d) The planning of reconstruction operations and checking the bony contours and relations after operation.

The results obtained in several of the conditions mentioned are shown in the illustrations.

It should be stated in conclusion that no attempt has been made to cover all the possibilities that are offered by this method of lateral roentgenography. Additional findings of value are undoubtedly still to be recognized.

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# PITUITARY ADENOMAS AND DIFFERENTIAL DIAGNOSIS

By J TOWNSEND TRAVERS, M D , *New York City*

THE advances of medicine to its present physiologic stage, in which it seeks to convert abnormally functioning tissues to normal, rather than to remove or ameliorate the end-processes of pathology, finds an important field of usefulness among the endocrine glands. Dysfunction of these glands may warp the human tissues before they have completed their development. In recent years, the pituitary gland has become recognized as the master gland, which sits in its protected position in the center of the skull, directing the progress of the human body by its indirect control of the other endocrine glands. Hy-

favor of a pathologic condition of this gland, since it is such a deep-seated organ, therefore, it behooves him to have a comprehensive knowledge of the diseases of the gland, so that he may make an intelligent diagnosis. Thus, while this paper is written from a roentgenologist's viewpoint it reviews those other factors of endocrinologic and clinical importance considered necessary for a proper evaluation of the roentgenologic findings in pituitary disease.

Pituitary tumors constitute 18 per cent of all intracranial newgrowths and are second to gliomas in frequency. The anterior portion of the pituitary gland is com-



Fig 1

Fig 1 Chromophalic adenoma early case showing expanded and atrophic sella turcica.



Fig 2

Fig 2 A chromophobic adenoma showing ballooned out sella thinned dorsum and atrophied clinoids and floor, there was no increased intracranial pressure

pertrophy or atrophy of the pituitary gland is reflected in the function of the adrenals, thyroid, parathyroids, and pancreatic islands. A great deal has been learned of late regarding this master of our destiny, but withal, it is but the beginning of our knowledge.

The roentgenologist is often among the first called upon to give some evidence in

posed of three cell types: one contains granules with an affinity for acid dyes (acidophilic), a second has granules with an affinity for basic dyes (basophilic), and the third type presents no attraction for dyes (chromophobic). Each type of cell is capable of producing an adenoma. With the formation of a tumor, we have a hypersecretory state, with the destruction of



Fig 3

Fig 3 Advanced chromophobic tumor, in almost complete destruction of floor, dorsum sellae, and posterior clinoids, similar to an extrasellar neoplasm



Fig 4

Fig 4 An acidophilic adenoma, showing expanded sella, hypertrophied sinuses and mastoids, a prognathous mandible and spurring of the cervical vertebrae

these cells by pressure atrophy, we have a hyposecretory condition. The acidophilic cells are known to produce the growth hormone, the basophilic cells are thought to produce a sex hormone, the chromophobic cells are not known to secrete any hormone.

This study of 25 adenomas comprises a period of nearly 10 years from the neurological and roentgenological services at Bellevue Hospital.

**Chromophobic Adenomas**—These tumors comprise two-thirds of all pituitary tumors. Their symptoms and signs depend on their state of growth: whenever a tumor is large enough to compress the other pituitary cells, amenorrhea and loss of libido occur, together with a lowered basal metabolism and "pituitary obesity." This is the syndrome formerly called hypo-pituitarism. Extrasellar extensions of the adenoma may cause polyuria, polydipsia, and drowsiness, due to hypothalamic pressure. When the tumor impinges on the optic chiasm, it causes primary optic atrophy and bitemporal hemianopia. The blindness is often

exaggerated on one side, as tumors are not usually symmetrical. The x-ray findings are typical; they disclose an expanded or ballooned-out sella turcica, or there may be erosion in the floor, with decompression of the tumor into the sphenoid sinus. The posterior clinoid processes and dorsum sellae are thinned or perhaps entirely destroyed. There is no general sign of increased intracranial pressure in these tumors except when an extrasellar extension of great size exists (Figs 1, 2, and 3).

**Acidophilic Adenomas**—These tumors comprise 25 per cent of pituitary adenomas. They secrete the growth hormone, therefore, gigantism results in the rare cases in which they occur in early youth. They usually are met with in middle life, after the closure of the epiphyses, and produce the picture of acromegaly. The tumor usually ceases growing before visual disturbances take place in the benign neoplasms. In the malignant form, the optic nerves are encroached upon, and the same optic nerve phenomena are exhibited as in

the chromophobic growths. These are the chief symptoms for which aid is usually sought. Constitutional disturbances

reported 19 cases of basophilism. In the first report, a postmortem on three of the eight cases examined showed a pituitary

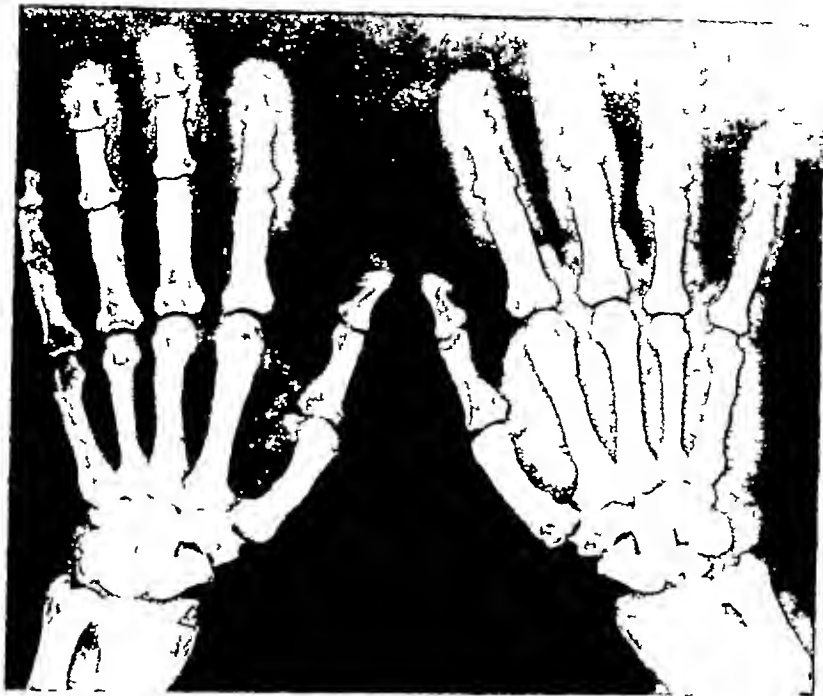


Fig 5 Hand of acromegalic showing characteristic changes, hyperostosis of phalanges and metacarpals terminal tufting, and minute cysts in carpal bones

caused by acidophilic adenoma are increased basal metabolism (unlike the chromophobic adenoma, which causes a hyposecretory state), enlargement of the hands, feet, sinuses, and facial features, amenorrhea and loss of libido (a hyposecretory state due to the pressure of the acidophilic tumor upon the basophilic cells). There are some cases of mild acromegaly or over-growth which otherwise are essentially chromophobic in type, such cases may be of a mixed type, including both chromophobic and acidophilic cells. The x-ray film of the sella turcica is similar to that of the chromophobic type, however, other x-ray evidence such as the hypertrophied mandible, sinuses, hand, foot, and face bones, clarify the diagnosis. These tumors seldom attain growth outside the sella turcica to produce signs of increased intracranial pressure (Figs 4 and 5).

*Basophilic Adenomas*—Cushing, in 1932,

basophil adenoma. In the second report, six of the 11 postmortem cases with the basophil syndrome showed a basophil adenoma. In two cases the pituitary was said to be normal, serial sections had not been made. The symptomatology of this lesion is protean, due to the influence of this gland on most of the other endocrine glands and, indirectly, on most of the body functions. The stimulation of the thyroid gland results in an accelerated basal metabolism. The stimulation of the parathyroid, with perhaps excessive parathormone secretion, activates the osteoclasts, with a consequent loss of calcium from the skeleton and its occasional accumulation in the excretory organs. These same effects upon the pancreas and adrenals result in glycosuria and pigmentation. The painful adiposity and hypertension is believed to be due to tuberal injury and invasion of the neurohypophysis by wandering basophilic



Fig 6

Fig 6 Case of basophilism, note osteoporosis of the skull



Fig 7

Fig 7 Spine in a case of basophilism, showing kyphosis due to osteoporosis

cells Finally, the secondary sex characteristics are affected, manifested by a loss of libido and amenorrhea The roentgen features of a basophilic adenoma are not characteristic The tumor measures from 1 to 3 mm and, therefore, is not of sufficient size to cause any changes in the sella turcica Nevertheless, the general osteomalacia present in all the bones is reflected in the skull where porous areas are discernible The posterior clinoid processes may seem eroded, due to their decalcification The spine may likewise become sufficiently decalcified to cause a kyphosis However, the striking clinical syndrome, as well as the general osteoporosis, calls attention to the true diagnosis (Figs 6 and 7)

*The Sella Turcica*—The sella turcica is normally bounded posteriorly by a thin wall the dorsum sellæ, which is a continuation of the body of sphenoid bone It is surmounted at its extremities by the knob-like posterior clinoid processes The floor forms the roof of the sphenoid sinus The

anterior wall is a continuation of the tuberculum sellæ upon which the olivary eminence is situated and is not usually visible Above this is the chiasmal sulcus, a groove at either end representing the opening of the optic canal On each side of the anterior wall of the fossa are overhanging anterior clinoid processes The sella turcica may normally be round, oval, or flat, depending on the development of the underlying sinuses A roentgenogram taken at a target-film distance of 36 inches will reveal the normal sella turcica of a patient over the age of twelve years to have a depth of from 8 to 9 mm and a sagittal diameter of 12 millimeters This has been regarded as a high normal but might suggest suspicions of an adenoma in a patient with symptoms Tumors may, of course, produce clinical symptoms and still be too small to be visualized Between the sixth and tenth year, a depth of 7 mm and a sagittal diameter of 8 mm is considered a normal sella turcica



Fig 8 Posterior fossa neoplasm deformed sella from enlarged third ventricle. Note destruction of floor, dorsum sellæ and posterior clinoids and disclosed increased intracranial pressure with presence of sub-occipital decompression

*Deformities of the Sella Turcica*—A deformed sella turcica is common evidence of an intracranial tumor. The intrasellar tumors cause atrophy of the anterior wall and dorsum sellæ, thinning them until they disappear. The floor becomes coincidentally thinner and depressed. The anterior clinoid processes lie outside the limits of the pituitary fossa and do not atrophy until late, when they become pointed. Suprasellar tumors are usually craniopharyngiomas. They show a picture similar to that of intrasellar growths, though not so marked, the depression on the floor being produced much later than atrophy of the posterior clinoid processes and dorsum sellæ. These tumors are generally calcified. Other suprasellar tumors, arising from the infundibulum and meninges, cannot be distinguished from a dilated third ventricle which usually causes atrophy, first of the dorsum sellæ, then of the posterior clinoid processes. After the disappearance of the clinoids, the dorsum sellæ



Fig 9 Suprasellar cyst or Rathke's pouch cyst. Note calcification of suprasellar region and atrophic dorsum sellæ

becomes pointed and then disappears. The floor not being equally atrophied, as in the ballooning of the intrasellar growths, the sella turcica consequently is broad in the sagittal diameter and less so in depth. Some writers believe that parasellar growths may produce unilateral formations indirectly, revealing, on roentgen examination, a double floor but changes are not a common finding (Fig 8).

*Differential Diagnosis* (Suprasellar cyst-craniopharyngiomas or Rathke pouch cysts)—The upgrowth of buccal ectoderm and downgrowth of the forebrain form the hypophysis, and, from the embryologic remnants of this canal, tumors called suprasellar cysts originate. They may be of three types: simple papillary cysts, cystic or solid, adamantinoma and malignant spindle-cell solid tumors. The second group is the common one and is named after the adamantoblast, which arises from the same buccal epithelium which later gives origin for the teeth. This portion of the aforementioned tumor is characteristically interspersed with calcium deposits and often bone formation, a factor of great importance in x-ray diagnosis. These tumors are usually cystic and are located above the pituitary gland and behind the optic chiasm, producing a clinical picture



Fig 10

Fig 10 Meningioma disclosing deformity of sella turcica, destruction of floor, dorsum sellae, and posterior clinoids, differentiated from intrasellar tumors by the dilated circulatory channels and hyperostosis of the inner table of the vault



Fig 11

Fig 11 Pituitary adenocarcinoma Note extensive destruction of sella turcica with no increased intracranial pressure

similar to that of a large chromophobic tumor with extrasellar extension, the chief differences being their calcification (in 85 per cent of the cases) and the extrasellar character of the deformity of the sella turcica associated with their usual occurrences in childhood. This is the most common cause of Frohlich's syndrome, a hypopituitarism seen in youth and caused by pressure on the pituitary body. These congenital tumors are rare in patients over eighteen years of age, whereas adenomas are uncommon below this age. A large congenital cyst may occasionally produce choked discs rather than optic atrophy. A homonymous hemianopia is more likely to be caused by a congenital cyst than by a pituitary adenoma (Fig 9). Primary gliomas of the optic chiasm must be considered in our differential diagnosis of pituitary tumors. Formerly, they were usually diagnosed as suprasellar cysts, due to the fact that they frequently occurred in the first decade, caused primary optic atrophy, visual disturbances, and similar sellar deformations

The following facts are of some help in the x-ray diagnosis of chiasm tumors. In advanced cases, there appears a recognizable extension of the anterior portion of the pituitary fossa which is demarcated from the sella turcica proper by an elevation made by the tuberculum sellae. The extension passes up under the anterior clinoids which may thus be elevated and thinned. The optic foramina may show enlargement due to pressure. Clinically, the process destroys vision more rapidly and does not show the same clean-cut temporal field defects that pituitary tumors do. Furthermore, a primary optic atrophy in the presence of a generalized neurofibromatosis should be suspected as being caused by a glomatous process in the chiasm. When a primary optic atrophy exists in a child, associated with the peculiar sella turcica deformation described, and without the usual shadows cast by the more common tumors in this neighborhood, we must consider the possibility of a glioma.



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Fig 14 Aneurysmal dilatation of the internal carotid artery, causing expansion and atrophic changes in sella turcica. Note the calcified streaks in the blood vessel. Stereoscopically, the calcifications are noted in the parasella region.



Fig 15 Calcified subdural hematoma adjacent to the sella turcica, having the appearance of a craniopharyngeoma. The history of trauma differentiates this lesion.

sella turcica simulating early intrasellar tumor. The increased intracranial pressure is found in extrasellar tumors and not in adenomas of the pituitary gland (Fig 13).

Aneurysmal dilatation of the internal carotid artery frequently causes a deformed sella turcica simulating a pituitary adenoma. The streaks of calcifications in the internal carotid artery situated in the parasella region differentiate the intra- from the para-sella lesions (Fig 14).

Calcified subdural hematoma may cause a deformity of the sella turcica which requires differentiation. A history of trauma and subsequent calcification will differentiate the two lesions (Fig 15).

Cushing states that some day the diagnosis of pituitary adenoma will be made as frequently as that of a thyroid adenoma and that the tumor exists undiscovered in many individuals to-day. When the entity is sought more often, it will be found not only in its grosser manifestations but in all the preclinical stages in which it exists unknown because of its mild nature. Diagnosis based on x-ray examination of the early tumors will be much more difficult, if not impossible, since their size will

not be sufficient to cause bone changes within the skull. The diagnosis as well as the prevention of these tumors may some day belong to the field of biological chemistry. However, life and sight are threatened only by the more advanced tumors. The x-rays are capable of confirming the presence of such growths. In the case of the basophilic tumor, the assistance of the x-rays is tremendously augmented by the characteristic clinical syndrome, so that today, even though our method of diagnosis is not accurate enough to detect the pathologic change in its incipency, we have advanced sufficiently to diagnose many of the heretofore confusing pituitary tumors with some degree of exactness, and define their size, physiology, and histology before they have inflicted irreparable damage.

I would like to acknowledge my debt of gratitude to Dr. Foster Kennedy and Dr. Lewis Friedman, Directors of Departments of Neurology and Roentgenology, respectively, for their kind co-operation.





Fig 12

Fig 12 Arteriovenous angioma Note effect of extrasellar pathology causing atrophy of posterior clinoids and dorsum sellæ The calcifications in the blood vessels and dilated circulatory channels show the extrasellar tumor



Fig 13

Fig 13 Deformity of sella caused by cerebral tumor, simulating pituitary adenoma and differentiated by increased intracranial pressure The convoluted atrophy is usually found in extrasellar neoplasm

Meningiomas, occurring in the suprasellar region, may cause deformation of the sella turcica. This is generally characteristic of most extrasellar processes, in that there is pressure atrophy of the skull, destruction of the posterior clinoids, and a boat-shaped flattening of the sella turcica rather than the ballooning of intrasellar growths. Clinically, they resemble Rathke's pouch tumors in that there is primary optic atrophy, bitemporal hemianopia, and the hypopituitary picture caused by pressure on the gland and the environs, with symptoms of polyuria, drowsiness, etc. However, they are distinguished from pituitary adenoma by irregular changes in the sella turcica and lack of ballooning (Fig 10).

Rathke's pouch tumors are differentiated by the fact that they commonly occur in childhood, while meningiomas are present in adults only.

Interpeduncular teratomas give rise to a clinical picture of hypopituitarism, produced by a chromophobic adenoma with early bitemporal hemianopia and primary optic atrophy. However, the neighbor-

hood symptoms, such as polyuria, call attention to the extrasellar nature of the growth. The x-ray may show complete absorption of all sellal landmarks in the advanced cases, there being nothing characteristic to distinguish it from other extrasellar neoplasms.

Cholesteatomas, occurring in the pituitary region, are rare and give an atypical symptomatology. A dilatation of the third ventricle, due to obstruction, presents a picture similar to suprasellar tumors. Ventriculography is informative. Malignant pituitary tumors, in an early phase, reveal a picture similar to benign growths, nevertheless, the rapid clinical course and extensive bone destruction will distinguish the malignant growth from the benign (Fig 11). Extrasellar neoplasms frequently simulate the intrasellar tumors. Arteriovenous angioma causes atrophic dorsum sellæ and posterior clinoids. The calcified streaks in the blood vessels and dilatation of circulatory channels disclose the presence of the extrasellar tumor (Fig 12).

Cerebral tumor causing deformation of

# THE ROENTGENOLOGIC STUDY OF THE MASTOID AREA<sup>1</sup>

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COMPARATIVELY little has been written about the mastoid in recent years. So little, in fact, that it would seem worth while to review the subject and the literature.

The mastoid antrum is an outgrowth of the tympanum that communicates with the tympanum through the auditus, it is present at birth, a cavity varying from  $7 \times 9$  to  $9 \times 11$  millimeters. The mastoid process, at birth, is a small tubercle that is gradually pushed downward as growth increases and the mastoid cells develop, the mastoid cells are in reality diverticula of the antrum. From above, the antrum is bounded by the roof of the tegmen-tympani, its inner wall is formed by the base of the petrous pyramid and its outer wall by the squamous portion of the temporal bone. This squamous bone in infants is not more than one or two millimeters in thickness but by the ninth year has usually increased to about ten millimeters.

According to Wittmack, in the third or fourth year, the mastoid antrum has assumed all the adult characteristics. He divides the development of the temporal bone into three periods: (1) Formation of the tympanum, epitympanic recess, and the mastoid antrum, continuing to the end of the first year, (2) formation of mastoid cells from these three cavities which ceases between the fourth and sixth year, (3) further formation of cells, which continues throughout life. Zuckerkandl says that pneumatization of the process begins about puberty, Koehler says that it continues throughout the life of the individual. Most anatomists agree that the large majority of mastoids are symmetrical, asymmetry can usually be taken as an indication of previous pathology.

There are two general classes, infantile

and pneumatic. Both Cheatle and Bigelow use this same classification. Law divides them into the non-cellular and cellular.

An infantile type consists grossly of an outer layer of compact bone, known as the antral wall, and an inner layer of fetal cells. Below this is the mastoid itself, either with a diploetic structure or solid compact bone. This latter type is spoken of as the undeveloped type, persisting throughout life without further pneumatization. From a roentgen viewpoint we recognize in the non-cellular types the following anatomical structures:

External meatus	Mastoid antrum
Internal meatus	Sigmoid sinus
Knee of the sinus	Tip of the process

The remainder is dense compact bone. Occasionally a small group of cells can be visualized in the antrum and less often a few between the auditory canal and the sinus.

While the diploetic type has much the same appearance as the undeveloped infantile type, it is most important that these small cells be accurately described so that they may be thoroughly curetted.

The sclerotic type also resembles the undeveloped type except that the osteitis produces irregular areas of sclerosis with alternating or interspersed groups of cells, while the infantile type is of a more homogeneous structure. Most writers are of the opinion that the sclerotic type is not a separate and distinct entity, but that it is a diploetic type which has been the seat of active inflammation, and that arrest of development and sclerosis naturally follow. The sclerosis will more than likely originate and be most pronounced about the knee of the sinus and progress toward the tip. Involvement of the antral area occurs at the expense of the cellular structures.

In the pneumatic type, all the anatomical

<sup>1</sup> Read at the Twenty first Annual Meeting of the Pennsylvania Radiological Society, Williamsport, Penna., June 5 and 6, 1936.

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are well outlined, the sinus groove is more or less distinct, and there is little or no exudate within the cells. Surgical intervention is seldom indicated, but a differential diagnosis must exclude post-auricular edema, eczema, or furunculosis of the canal.

Should the clinical symptoms of such a case become more acute, re-examination in a few days will more than likely reveal an acute purulent mastoiditis with greater opacity of the area, cells filled with exudate, the trabeculae thickened (softened), and the anterior edge of the sinus groove preserved and more sharply outlined. Simple myringotomy usually restores the normal pressure, and if drainage is adequate, complete resolution takes place.

Cessation of drainage with unfavorable clinical symptoms is a definite indication for re-examination. Surgical intervention is required if the exudate increases and the cells coalesce. The visibility of the anterior edge of the sinus groove is a most important guide in advising surgical intervention. Granger has always maintained that in infants, when the sinus groove is visible, surgical intervention is indicated. This same observation was made by Taylor, previous to Granger's publication. Taylor said "When the mastoid becomes involved, the sinus wall usually appears very prominent, due to the change in the density of the mastoid cells. Consequently when, on comparing the two sides, the sinus wall appears more prominent on one side, it is significant of involvement of that side."

Necrosis of the trabeculae means abscess formation. Since the antrum is in most cases the original site of infection, we expect to find necrosis first in that area.

Next in order would be its extension to and involvement of the sinus groove, with the formation of a perisinus abscess, revealed by solution of the continuity of the sinus wall. When the continuity of the tegmen is broken, there is grave danger of internal perforation and the formation of an epidural abscess. The progress is too

rapid for new bone formation, so the wall of an abscess would not be sharply outlined. On the other hand, cholesteatoma is the result of a chronic suppuration with definitely circumscribed borders, due to an osteitis, while a cyst would have its smooth wall and homogeneous cystic contents.

In the infantile or undeveloped type the diagnosis is much more difficult. One may temporize with a fair degree of safety in the pneumatic types, but in the non-cellular types the situation is entirely different. Because of the thick outer antral wall, infection may progress for a long period without visible external mastoid signs. Intracranial complications through the posterior wall have been known to occur without giving very marked superficial indications. Very often a small group of cells between the posterior wall and the sinus is the only cellular structure visible. When such an infection is confined to the mastoid area it becomes that bug-bear of the otologists, a chronic suppurative mastoiditis. All non-cellular types, infantile, sclerotic, or diploetic, with acute symptoms should, according to Gerber, have the antrum explored early in order to prevent chronicity.

A fourth variation of the pneumatic group is the double-decked type in which a false inner table separates the outer cells from a rich diploetic structure. While not common, it is by no means rare, Gerber and Law both speak of it. The responsibility for its diagnosis rests solely with the roentgenologist. The fine details must be reported to the surgeon or he will discontinue his exploration when this false inner table is reached, and leave a large area of small infected cells untouched. The only case of this kind seen by the writer had a persistent discharge after a second operation, and eventually developed a petrositis. This case was later operated on by Kopetsky.

While suppuration of the petrous pyramid has been recognized for many years, it has been given more serious consideration since the publications of the monographs of Kopetsky, Eagleton, Taylor, and others.

cal features of the infantile type are present in addition to the air cells with their bony trabeculae. The real difference between the two types lies in this cellular structure.

The additional anatomical structures that are of prime importance are the posterior wall of the auditory canal, just posterior to it and possibly separated from it by small cells lies the aqueductus fallopianus containing the facial nerve. Posterior to this is often found another group of cells in front of the anterior wall of the sinus groove.

The lateral sinus transverses the mastoid process from behind forward. At about the level of the antrum (the knee), it bends downward and at the level of the tip enters the jugular bulb. It lies in a groove, the borders of which form most important landmarks. As pneumatization progresses, the groove becomes more distinct.

The tegmen tympani lies above the canal and the antrum. Above the line of the tegmen is the squamous portion of the temporal bone into which the pneumatization may have extended.

The temporal bone, the glenoid cavity, and the condyle of the jaw mark the outer borders of the mastoid area. In exceptional cases cells may be found extending as far forward as the root of the zygoma or backward into the occiput.

While the pneumatic group is divided usually into three types, a large celled type, small celled, and mixed celled, there are encountered all sorts of combinations. Fortunately, in most cases, the large cells will be found about the periphery, often at the tip. Such cases invariably drain better than those in which the small cells comprise the borders. Combinations of cellular and non-cellular types occur.

Pneumatized spaces, when present and normal, have a very thin mucosal lining, a muco-periosteum that consists of a scantily vascularized fibrous layer covered with a single layer of flattened squamous cells. When there is only partial pneumatization, the muco-periosteum rests directly on the marrow-containing spaces or a very thin layer of bone separates air-con-

taining spaces from marrow. The blood supply for the mucosa, bone, and marrow comes from small regional vessels. No studies have been made of the lymphatics of this area.

The pathology varies according to the structures, osteitis can occur only in a pneumatized structure, while osteomyelitis occurs in bone which contains marrow, either red or yellow.

Infection in the tympanum, with edema and pus formation, obstructs the eustachian tube. The air in the antrum is quickly absorbed and the change from the positive to negative pressure encourages bacterial growth, the antrum and cells soon fill with exudate and produce the characteristic roentgen appearance. If simple drainage, myringotomy, relieves the pressure, restoring the positive pressure, the exudate is absorbed, the edema disappears, and the clinical symptoms improve. The antrum lies about 9 mm above the floor of the tympanum, and the surface of the eustachian tube is 4 mm above it, so that there must be considerable pus and edema before these structures are involved.

When drainage is inadequate the pressure plus the infection involve the trabeculae. Osteitis progresses to necrosis, the cell groups coalesce, and abscess results. Necrosis usually begins at or near the knee of the sinus, extending to and involving the sinus covering. External rupture is rare. Unfortunately, the destruction progresses internally, with the formation of an epidural abscess or what we now regard as another distinct clinical entity—suppuration of the petrous apex.

The roentgen value of a mastoid examination, as defined by Law, "is equal to the interpretation of the film plus the technic divided by the clinical evidence." In other words, no matter how careful and extensive the roentgen examination, the clinical phase is first.

A mild acute mastoiditis occurs in all middle ear infections. Due to the hyperemia and passive congestion, the involved side is more radiopaque. The structures do not lose their identity. The trabeculae

will visualize certain structures to good advantage, but at the expense of others. The Stenvers position is valuable not only to demonstrate the mastoid cells but the contours of the pyramids. In this position the sinus is not as clearly defined as in the Law position. A reverse of the Caldwell position gives one an additional view of the pyramids, but will not visualize the cellular structure at the base of the pyramids. In the Caldwell position the pyramids are within the orbits.

The Arcelin or Granger position, the reverse of the Stenvers position and the Löw-Beer position, will add information to that already derived from the other three. It is not a question of how many films but how good, how closely we can correlate the roentgen interpretation to the physical findings, and the symptoms.

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The first operation for drainage of the petrous apex was performed in 1929, although the apex had been drained by following a sinus as early as 1893. Gradenigo's first monograph was published in 1904, the second in 1907, and Kopetsky's in 1930. Since then there has been a great deal written on this subject.

These cells, like the antrum, are likewise an outgrowth from the tympanum, and it naturally follows that infection of the tympanum will cause the same train of pathology as occurs in the antrum. Unlike mastoids, the petrous pyramids are not symmetrical. The cells arise from four different areas and tend to spread in tracts converging toward the apex. The distal third of the pyramids are marrow bone and are usually non-cellular. Drainage occurs through the middle ear and is accelerated by myringotomy or simple mastoidectomy. The tendency of petrous infection is to undergo spontaneous resolution. Failure of adequate drainage results in early infection of the meninges—acute suppurative type of petrositis. A chronic suppurative type has been recognized by some writers.

The symptoms, according to Lillie, are homolateral orbital or retro-orbital pain, continuous drainage, and low grade sepsis. Sixth nerve paralysis may occur. He says this syndrome should not be confused with Gradenigo's syndrome, which is not characteristic of any specific lesion. The onset of symptoms usually occurs from ten days to two weeks following a simple mastoidectomy.

In the pneumatized pyramids, the roentgen findings of pathological significance are diminished aeration, deficient trabeculae, intense atrophy, perforation, and destruction of the apical contour.

For a detailed description of the anatomy of this portion of the temporal bone, one should consult the standard works of anatomy, or, better still, the excellent monographs that have been published since 1930. Wedged in between the sphenoid and occipital bones, this pyramid lies in close contact with seven cranial nerves (5 to 11, inclusive), the Gasserian and geniculate

ganglia. More than half its surface is covered with dura. The tentorium cerebelli is attached to its superior angle. It lies near to the lateral border of the nasopharynx, and two palatal muscles take origin from its under surface. The trigeminal nerve is separated from its apex by a layer of dura. The superior petrosal sinus is above and behind it. Below and in front are found the jugular bulb, carotid artery, and the inferior petrosal sinus. Some part of the pyramid is in close relation to the superficial petrosal nerves, the nerve of Jacobson (tympanic branch of glossopharyngeal), and the carotid sympathetic trunk.

A structure which is so closely related to the tympanum, the mastoid, and so many of the cranial nerves and blood vessels, must necessarily be included in any study of the temporal bone. Since the symptoms so often follow a mastoidectomy, and on account of the many variations in type and symmetry, the radiographic record of the pyramids made before operation will be of greater value for comparison if it becomes necessary to re-examine after mastoidectomy.

What positions and how many films are required for an adequate examination of the temporal bone? Should the Bucky diaphragm be used? It would seem that the 15° angle position made stereoscopically with both mastoids on the film, without the Potter-Bucky diaphragm, is the rational procedure. This should be supplemented with postero-anterior stereoroentgenograms in the Caldwell position, forehead and nose at a 23° angle. The vertex-submental or the sub-mento-vertex positions, stereoscopically will visualize the pyramids to the best advantage. The former is easier in long-necked individuals, but difficult in short, stout persons. The sub-mento-vertex Taylor position is rather unpleasant for some patients, occasionally producing vertigo, but very valuable when obtained. These three positions will permit examination of the temporal bone in three different planes and should be considered adequate.

There are many other positions which



Fig 1

Fig 1 Case 1 Boy, 7 years old Area of decalcification in the right ischiopubic synchondrosis with well defined edges and a crumbly structure Osteochondrosis ischio pubica.



Fig 2

Fig 2 Case 2 Girl, 6 years old A well limited focus of decalcification in the right ischiopubic synchondrosis Osteochondrosis ischio-pubica

gards them as complications of the primary process, however, such complications are not known in osteochondropathies of other localization Haberler (7), considering this, states that in his cases of osteochondritis ischio-pubica, as well as in other cases described previously, there took place a chronic unspecific process, which from the first arose as such As a matter of fact, Odelberg (18) at an earlier date described three cases with lesions in the ischio-pubic synchondrose, in children between the ages of 11 and 15 years, very similar to the disease which was later described as osteochondritis ischio-pubica During the operation the author obtained a round brownish mass, rich in cellular elements and plasmatic cells, with a small addition of leukocytes Bacteriologic investigation and inoculation of animals proved negative After periods of one, two and one-half, and three years, respectively, the children recovered The author excludes syphilis, tuberculosis, and ostitis fibrosa in his cases, supposing that here a peculiar inflammatory process took place

The Haberler-Odelberg conception of the inflammatory nature of the changes in osteochondritis ischio-pubica very well ex-

plains the clinical and roentgenologic symptoms of many cases but not of all It does not explain cases in which limited areas of decalcification appear in the synchondrose and the clinical course is symptomless or with very mild symptoms, even these disappearing within a short time Heeren, Janker, and others had just the cases in view, we also had some under our observation There is no good evidence to suppose that these changes are the primary stage of a typical osteochondritis or an abortive form of it We are more inclined to consider them as changes in the normal process of ossification, as may be observed in the other parts of the skeleton, without any inflammatory basis Such changes must be a common finding in processes that are accompanied by retarded ossification of the cartilage As a matter of fact, Engelmann mentions that, in congenital unilateral dislocation of the hip joint, abnormalities often occur in the region of the synchondrose Here also might be referred the Dickson Wright (4) case of a boy aged 11 years, who had, together with osteochondropathy, irregular blurred outlines distributed in many epiphyses of the ischio-pubic synchondrose



# OSTEOCHONDROSIS-OSTEOCHONDritis ISCHIO-PUBICA

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THROUGH extensive roentgen investigation in bone diseases of children, we have been able to distinguish a special group of lesions in the osteochondrial part of the epiphysis of the growing bone, which are at present united under the name of epiphysitis or juvenile osteochondropathy. Such changes have been found in the different parts of the skeleton. To the uncommon localization of this process belong lesions of the ischio-pubic synchondrose, first described by Van Neck, in 1924, under the name of osteochondritis ischio-pubica. After his first publication there appeared a number of other papers describing similar cases: Valtancoli (22), Wulfig (25), Asplund (1), Manfredi (16), and Hirsch (11), and others. We do not propose to give here a historical review of the literature since it can be found in most works on the subject. In general, there could be quoted about fifteen more or less full descriptions of cases of osteochondritis ischio-pubica, but each author had under observation not more than from one to three or a maximum of four cases. Therefore, the more surprising was Heeren's report (10). This author, on studying 95 roentgenograms of the pelvis of children aged from 2 to 12 years, found lesions in the ischio-pubica synchondrose in 33 cases, which he also classified under the above disease.

The considerable difference in the number of cases makes a more critical consideration of the question warrantable, also, a dissimilarity in the clinical and roentgenologic picture described by the author causes yet further perplexity. According to Heeren, in many cases the typical changes in the synchondrose are symptomless, only being accidentally discovered by a roentgenogram, in other rarer instances, the cases reveal only slight clinical symptoms. Whereas, Asplund, Van Neck, and Wulfig

describe more or less serious symptoms, such as rise of temperature, local swelling and edema, a spasm of adductors, and pains in the hip joint which cause a condition that may be mistaken clinically for coxitis tuberculosis. In some cases only a short rest cure is sufficient to insure complete disappearance of all manifestations of the disease, in others, the process continues for months and years. As regards the roentgen picture, Van Neck, Valtancoli, and Heeren consider as characteristic changes the formation of an oval focus of rarefaction in the region of the synchondrose, sometimes with distinct sclerotic outlines without reactive manifestations in the surrounding tissues. On the other hand, Asplund, Haberler (7), Engelmann (6), and others describe definite destructive and reactive changes in the adjoining bones, with sequestration and purulent fusion in some cases.

These various and contradictory descriptions of osteochondritis ischio-pubica presented by the authors make it doubtful as to whether in all cases the same disease had been under observation, i.e., the juvenile form of osteochondropathy. Quite often symptoms described by some authors differ from all that we know about this disease. True, the etiology and pathogenesis of juvenile epiphysitis are still not definitely established, however, most of the writers agree on the fact that the condition is least of all caused by a common inflammatory process. The diseases known as Köhler's, Perthes', Osgood-Schlatter's, Kienböck's, Preiser's, and others similar to these do not appear clinically as acute infections, with high temperature, and we do not know of any instances which have ended with sequestration and suppuration. Heeren ascribes these changes to secondary infection at the site of the lesion and re-



Fig 5

Fig 5 Case 3 Roentgenogram taken in 1935, 1 year 5 months later than Figure 4 Note in the region of the right synchondrosis some separate round areas of decalcification with condensed periphery The left ischiopubic branch is hazy and mottled on the medial contour



Fig 6

Fig 6 Case 4 Girl, 7 years old Roentgenogram taken in 1929 The medial part of the left ischiopubic region is occupied with areas of decalcification with uneven edges A small promontorium is to be seen on the right ischiopubic branch

thigh when walking The leg is flexed, with painful abduction, the temperature is normal or slightly raised Local manifestations are seldom observed, such as swelling at the place of symphysis or labia majores in girls, pain on palpation, and swelling in the inguinal fold All these symptoms either disappear quickly or remain for some time The diagnosis is based on roentgen findings

#### THE ROENTGEN PICTURE

In case of osteochondrosis ischio-pubica, there appears in the region of the synchondrose an oval or round focus of rarefaction, sometimes of crumblike structure, with distinct contours The focus, which rarely spreads over the entire width of the bone, leaves strips of normal tissue on the medial and lateral sides, sometimes even condensed on the side of the angulus pubis Very characteristic is the projection of the bony cartilaginous mass in the form of a triangular promontorium in the lumen of the foramen obturatorium Such a promontorium is sometimes observed as a variant in a case of normal ossification, but it does not reach such large proportions as in osteochondritis ischio-pubica The edges of the decal-

cified zone on the side of os pubis and os ischi, remaining well defined, become condensed in some cases and appear sclerotic in character The adjoining bone is normal The focus remains in such a condition for from a few weeks to several months, then begins a gradual process of restitution, the bone taking on a normal appearance and only the promontorium into the lumen of the foramen obturator, retarded in its restitution, remaining of the former process

In the above described form the roentgen picture is so characteristic for osteochondrosis ischio-pubica, that it can hardly present any difficulties for differential diagnosis The diagnosis is yet further clarified if there are corresponding changes in the other synchondrose, but there they are less clearly revealed and must be carefully searched for

In cases of osteochondritis ischio-pubica, the pathologic process is more clearly revealed with regard to the intensity of the changes and their development The process of decalcination and dystrophy is not limited to the synchondrose but is transferred to the adjoining part of the os pubis and os ischi, forming one continuous focus or appearing as a number of separate spots

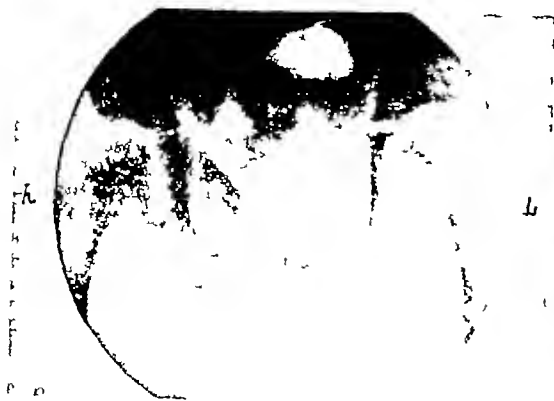


Fig 3

Fig 3 Case 3 Boy, 6 years old Roentgenogram taken in 1933 In the right ischiopubic synchondrosis there is a very large area of decalcination, well limited above and below The medial contour in this zone is indistinct, the lateral, well defined In the left synchondrosis are two little areas of rarefaction Osteochondrosis ischio-pubica



Fig 4

Fig 4 Case 3 Roentgenogram taken in 1934, 15 months later than Figure 3 The decalcified zone in the right synchondrosis is markedly decreased and distinctly outlined The decalcination in the left is hardly discernible

This group of changes in the ischio-pubic synchondrose, which has as its basis an impairment of the normal process of ossification and which is related or similar in its pathogenesis to osteochondropathy, we propose to designate as osteochondrosis ischio-pubica, thereby distinguishing it from the other form known as osteochondritis ischio-pubica, characterized by an inflammatory process

#### DIAGNOSIS

Undoubtedly, etiologic analogous processes give morphologically different pictures in the bones, depending on the localization of the lesion and age of the patient, inasmuch as the development of the focus is influenced by the anatomical and functional peculiarities of the particular region of the bone, its structure, blood supply, mechanical strain, etc. From this point of view, changes in the synchondrose must vary from analogous processes in other localities. The ossification of the ischio-pubic cartilage occurs, according to Braus and Schinz (20), at the age of from six to eight years, according to Hasselwander (8), at the age of from seven to eight years, and according to Valtancoli (22), at eight years. With that age are associated most

of the cases of osteochondritis ischio-pubica, rarely are children from 11 to 12 years mentioned. At this stage of development, Haberler thinks that the localization of the process in this disease must be connected with special construction of the vessels. The roentgenologic architectonic of the bones of the pelvis is well studied by Balli (2), who describes extensive development of a spongy mass in tuberositas ischi and peculiarities in the structure of ramus descendens ossis pubis, in which case the spongy bone consists of large cavities limited by thin partitions. As studied by Heeren (9), there are still more transparent areas in the normal child pelvis, which must be well known so as not to be mistaken for pathologic manifestations. In cases of osteochondritis (-osis) ischio-pubica, the lesions localize in the synchondrose itself and the adjoining bony regions.

As already mentioned, the clinical symptoms in this disease vary from complete absence of subjective complaints and outside manifestations, to expressly revealed symptoms, that may lead to a mistaken diagnosis of coxitis tuberculosis. With this diagnosis the children are usually sent for roentgen investigation. The child complains of a pain in the hip joint or in the



Fig 9



Fig 10

Fig 9 Case 4 Roentgenogram taken in 1933, one year later than Figure 8 The left ischiopubic branch appears quite broad and massive. The defects in the right os pubis are filling up

Fig 10 Case 4 Roentgenogram taken in 1935 2 years 3 months later than Figure 9 The bones are broader and more condensed The symphysis outlines are irregular, festoon-like The structure of bone in the synchondrosis region is well developed

time For differential diagnosis, much more difficulty is encountered in cases of tuberculosis of the ischiopubis in the reparative stage when the edges of the foci begin to condense Thus, for example, Ingber (12), in his work on tuberculosis of this region, presents some roentgenograms very similar to those we find in osteochondritis Similar roentgenograms are submitted by Engelmann in his work In such cases only a long systematic clinical and roentgenologic study of the condition, with consideration of all the data, can aid toward a correct diagnosis

#### PERSONAL OBSERVATIONS

We present here some of the personal observations which we consider typical for osteochondrosis and osteochondritis ischiopubica

Case 1 N S a boy, aged 7 years, who, as an apparently healthy child, two weeks previous to examination, developed in the right leg a pain which was especially noticeable after running The physician found no objective changes A few days later all complaints disappeared However, in order to exclude coxitis a roentgenogram of the pelvis was made (Fig 1) Except for a slight bilateral coxa valga, no

abnormalities were revealed in the hip joint, but in the region of the right ischiopubic synchondrose could be seen an area of decalcination the size of a nut, with well-defined edges and a crumbly structure The decalcination spread also upon the promontorium into the lumen of the foramen obturatum

Case 2 S I a girl, aged 6 years, the daughter of healthy parents, whose anamnesis and clinical findings are an exact repetition of the above described case The pain was localized in the region of the hip joint and upper part of the femur A roentgenogram of the pelvis, taken in 1935 (Fig 2), revealed that both hip joints were normal in appearance In the region of the right synchondrose, a limited focus of decalcination could be observed, similar to the one found in Case 1 There was also a promontorium into the lumen of the foramen obturatum Four days later the child was quite well, running about and playing as usual A roentgenogram taken later clearly revealed the focus with its edges slightly sclerotic There were no noticeable changes in the other bones A roentgenogram taken in 1936 showed the same picture

Case 3 C E, a boy, aged 6 years, was



Fig 7



Fig 8

Fig 7 Case 4 Roentgenogram taken in 1929, five months later than Figure 6 Several round irregular foci are seen in the left ischiopubic branch The concave edge of the right os pubis is irregular

Fig 8 Case 4 Roentgenogram taken in 1932, 2 years 3 months later than Figure 7 The edges of the deficient area have become more condensed and straightened

There are no reactive manifestations or they are very slight. The process is of longer duration, continuing from several months to years. In far advanced cases, the deformation of the bone is quite considerable and this stands in contradiction with the complete absence of clinical symptoms. We have observed no sequestration of the bone, and think that the cases in which it takes place do not belong to the group of the disease under observation.

#### DIFFERENTIAL DIAGNOSIS

In differential diagnosis, syphilis, osteomyelitis, and tuberculosis must be excluded. As a rule, syphilis of the bones of a purely destructive form is seldom met with, especially in the region of the ischiopubic bones, the characteristics of this disease are a thickening and condensation of the bone in its cortical and spongy layers. To these, may be added the typical nocturnal pains, the anamnesis and finally the serologic reactions. Osteomyelitis of the ischiopubic synchondrose has been many times described in the recent literature, both in adults (Soderlund (21), Peirson (19), McWhorter (24) and by many others), and more seldom in children (Doran and Brown (5), Klemm (14), En-

gelmann (6), and others). In the ordinary acute and subacute forms of osteomyelitis, beside a more sudden onset of the disease and more clear picture of general malaise, with a corresponding change in the blood, there is usually observed a more rapidly progressing process in the bone, having more pronounced reactive changes in the surrounding tissues, sequestration, and purulent fusion. If, on examination of the child, a fluctuating swelling can be found in the region of the symphysis or anywhere near, and if on incision pus is obtained or a fistula is formed, a benign non-specific osteochondritis in the sense described above is excluded. In the early stage of tuberculosis we also have a focal decalcination of the bone, which makes these conditions similar to osteochondritis ischiopubica, but in tuberculosis the rarefaction of the bone is more diffused and less limited on the periphery of the focus. According to Madlener (15), tuberculosis is localized more often in the branches of the os pubis, and only in severe cases does it also affect the rami of the ischium. Pathologically, we have here a caseous form of osteitis tuberculosa, which gives secondarily a rapid process of fusion, causing sequestration, abscesses, and fistula within a short

sis of osteitis fibrosa, others did not exclude the possibility of a neoplasm and suggested a biopsy. Our diagnosis lay between osteochondritis ischio-pubica and osteitis tuberculosa. No biopsy was made. The child spent the summer in the country, under calcium treatment and taking a complete rest. Toward autumn she walked normally without any limp. There remained a slight pain in the region of the os pubis, but on pressure only. Her temperature continued to be normal as always. Gradually the child was allowed to move about more and more actively. At the beginning of 1930, she was running about, and in winter was allowed to skate and dance with other children. But in spite of general well being and absence of local manifestation, the process in the bones continued its development, as is indicated by the roentgenograms, taken periodically. A roentgenogram, taken in 1929, revealed that on the left, the decalcination process spread upon the adjoining part of the os ischi, and on the right, a small round area of rarefaction in the ischiopubic synchondrose could be discerned. A roentgenogram, taken in 1929, revealed an area of decalcination clearly shown on the left, in the region of the tuberculum pubicum, an ossified promontorium was formed, with irregular contours. On the right, in the region of the symphysis, the contour of the pubic bone, formerly straight, had become concave. Another roentgenogram, taken in 1929, revealed an indistinct medial contour of the left pubic bone, with several rounded irregular foci. The promontorium was more pronounced. The concave edge of the right pubic bone was irregular and jagged (Fig 7). A roentgenogram, taken in 1930, revealed the left pubic branch to be more condensed. The area in the os ischi near the lower edge of the foramen obturatum, which formerly had been hardly discernible, had become more distinct. The irregularly shaped promontorium near the symphysis had a more definitely ossified structure. On the right side the changes remained the same as they were formerly. A roentgenogram, taken

in 1932, revealed that the bones of the pelvis had become more massive. The edges of the deficient area were condensed and straightened, but remained slightly festooned (Fig 8). A roentgenogram, taken in 1933, revealed that the space in the symphysis had become narrower, but its edges were irregular and festooned. The defects in the right pubic bone were filling up. The left ischiopubic branch appeared quite broad and massive (Fig 9). Another roentgenogram, taken in 1934, revealed that the growth of the bones and the filling up of the defects still continued.

A roentgenogram, taken in 1935, revealed a fissure in the narrower symphysis, but its edges were still irregular and crumb-like in appearance. The structure of bone in the synchondrosis was well developed. On the left, in the region of the foramen obturatum, are two small, millet-sized calcified nodules. The enostosis in the left iliac bone had reached the size of a large pea (Fig 10).

#### DISCUSSION

Thus in the first two cases, the children aged from six to seven and one-half years, alongside with insignificant, quickly disappearing complaints and complete absence of objective clinical symptoms, roentgenograms revealed a focus of decalcination in the ischiopubic synchondrose, strictly localized, without any reactive changes in the surrounding bones. Our patients' good health continued during several months of observation. In cases of other roentgen investigation, similar areas of decalcination have been observed in children in the region of the pelvis, for instance, after a trauma, or when calculi of the cystis were suspected, etc. We classify our cases 1 and 2 under the group of osteochondrosis.

The third case presents more difficulties for diagnosis. The swelling in the inguinal fold, without other clinical manifestations, led to the finding of round decalcinated areas with sclerotic edges in the ischiopubic branch. The process had already continued in this case three years, and could

the son of healthy parents. His only childhood disease was measles, which he had at the age of 5 years. His first complaint was of an itching in the right inguinal fold. On examination, the mother found a small swelling in this region. The temperature, according to his parents remained normal. A physician found some restriction of mobility in the right hip joint, and, suspecting the onset of coxitis, sent the child for roentgen examination in 1933. The boy has a strong and healthy appearance. Motion in both hip joints was painless, abduction on the right side was slightly restricted. On palpation, a slight swelling was felt in the inguinal region above the pubis, descending to the perineum. Pressure on the os pubis caused no pain. The roentgenogram (Fig 3) revealed the following: both hip joints are perfectly normal, the configuration of the symphysis corresponds to the age of the boy. The synchondrosis between the os pubis and os ischi is not yet quite ossified, on the right side in this region can be seen a large area of decalcination that spreads over both bones and is limited above and below by well-defined semicircular lines. The medial contour of the ischiopubic branch in the affected zone is indistinct, while the lateral, corresponding to the edge of the foramen obturatum, is well defined. On careful examination, to the left in the region of the synchondrose may be seen two small and indistinct areas of bone rarefaction. There is a slight condensation, with a promontorium into the foramen obturatum. A roentgenogram, taken in 1933, revealed that subjectively there are no changes. The boy runs around and does not complain of any pain or disability.

A roentgenogram taken in 1934, showed that the changes in the bones remained the same. During the year the boy noticeably grew, and was ill with "grippe" only once for a short time. The swelling in the inguinal region disappeared altogether. A roentgenogram at this time revealed an almost complete joining of the os pubis and the os ischi (Fig 4). The decalcinated zone on the right side was markedly decreased, but

much better defined on account of a thickening of its edges. The condensation was especially marked in the lateral zone. The decalcination on the left side was hardly discernible. The boy continued to feel well, playing and running about as usual, but on insistent questioning admitted that after strenuous running he felt a slight pain in the hip region (Fig 5). The decalcination zone in the synchondrose region appeared as a conglomerate of separate round areas with a condensed periphery. The triangular promontorium into the foramen obturatum was also changed. On the left, the medial edge of the ischiopubic branch was hazy and mottled, in the rest, the bones were normal.

Case 4. N. E., a girl, aged 7 years, is the daughter of a physician. Her history (written by the mother) is as follows: was born at term and developed normally. In February, 1929, she had measles, a few weeks after recovery from which there was noticed a slight change in her walk, she had acquired a limp. When questioned, the child complained of a pain in the inguinal region. Palpation produced a slight pain there. Her internal organs were normal. The urine contained no albumin. A roentgenogram of the pelvis, taken in 1929, permitted exclusion of coxitis, but in the ischiopubic region the following changes were found (Fig 6): on the right side, the ischiopubic branches were completely joined, and on the left there were signs of epiphyseal space. In the ramus descendens of the left os pubis, starting almost from the symphysis, there were areas of decalcination with uneven festoon-like edges occupying the medial part of the bone. The medial contour of this portion of the bone was only slightly outlined, while the lateral outline gave a clear picture. On the right ischiopubic branch was observed a small promontorium into the lumen of the foramen obturatum. In the left ilium near the joint was a thickening of the structure, the size of a pea (enostose?).

The opinion of the surgeons regarding the nature of these findings in the bone were divided. Some insisted on the diagno-

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not as yet be considered finished. We are inclined to consider this case also as osteochondrosis, relying on the fact that the process is limited to the region of the synchondrose, without any destructive changes in the surrounding bones. The chronicity of the process does not speak against our conclusion, since we know that also, in other osteochondropathies, years are sometimes required before complete recovery is achieved.

Case 4 we classify as osteochondritis. The clinical symptoms here were also few and soon disappeared, but the changes in the bones that started in the synchondrose gradually spread upward and downward. During the seven years that the case had been under observation, the reparative process had not yet set in and the bones had not recovered their normal appearance.

In all the cases presented by us, the diagnosis was based on the roentgen findings. We did not consider it advisable to verify our diagnoses by biopsy or incision, as Van Neck, Asplund, and others have done, since we consider that all such measures should be carried out in children only in cases of definite clinical indications. In these cases no such indication was present; the children felt well, their temperature remained normal, the function of the lower limbs was not disturbed, and the general development of the children was good. The prognosis for both forms of the disease is on the whole favorable, and we consider ourselves warranted in recommending the method of waiting, keeping the child under constant roentgen control.

#### CONCLUSIONS

(1) The disease that is at present described under the name of osteochondritis ischio-pubica, according to clinical and roentgenologic findings should be divided in two groups. The first is nearer to the picture that we see in osteochondropathy of juvenile age, and can be designated as osteochondrosis ischio-pubica, the second has at its basis a chronic inflammatory proc-

ess and retains the designation of osteochondritis ischio-pubica.

(2) In the simplest cases the diagnosis is quite easy, but in more complicated conditions longer observation and more systematic roentgen control are required.

(3) The prognosis in osteochondrosis is quite favorable, and no special methods of treatment are required. In osteochondritis the prognosis in general is also favorable, but the bone lesions are much greater and the deformation in the symphysis can possibly play a certain rôle in the future for girls, during childbirth.

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tial to our method The target-film distance is always 32 in (not essential), the target-inlet distance is recorded A film in the horizontal position (parallel to the plane of the pelvic inlet) is exposed and processed in the usual manner The image of the pelvic inlet (its planeogram) is transcribed to a sheet of paper for convenience of construction (Fig 1)

(A) *Angular Mensuration* (Fig 1)—As I have stated before, angular measurements may be made directly from the planeogram without correction Any angle ( $D_2-C_2-E_2$ ) in the planeogram is identical with the homologous angle in the inlet This means that any angles measured in the planeogram are true angles, suffer no distortion, and need no corrective procedure

(B) *Linear Measurements* (Figs 1 and 2)—Linear measurements in the planeogram are not true distances, since the planeogram is a distorted image of the plane These distances must be corrected For this purpose we have constructed the correction triangle,  $F-F_1-F_2$  (Fig 2), with  $F-F_2$ , the horizontal arm, equal to the target-film distance and  $F-F_1$ , the vertical arm, equal to the target-inlet distance If one wishes to measure the distance  $C_2-D_2$  (Fig 1), this distance is applied along the horizontal axis of the correction triangle, and the corrected distance,  $X$ , read along the vertical axis,  $C_2-D_1$  (Fig 2)

(C) *Reconstruction of the Plane of the Pelvic Inlet*—Two methods suggest themselves (1) Radial method, and (2) Perimetric method

For the radial method, any arbitrary, more or less central point,  $C_2$ , is chosen From it several radii,  $C_2-D_2$ ,  $C_2-E_2$ ,  $C_2-F_2$ , etc., are drawn to strategic points on the circumference of the inlet  $C_2-D_2$  is measured and applied to the correction triangle Its corrected distance,  $C_1-D_1$ , is applied along the radius,  $C_2-D_2$   $D_1$  represents one of the points on the true graph of the pelvic inlet The process is repeated for other radii, until sufficient points in the graph are located These

points are then joined by appropriate connecting lines

For the perimetric method, as before, radial lines are drawn and point  $D_1$  lo-

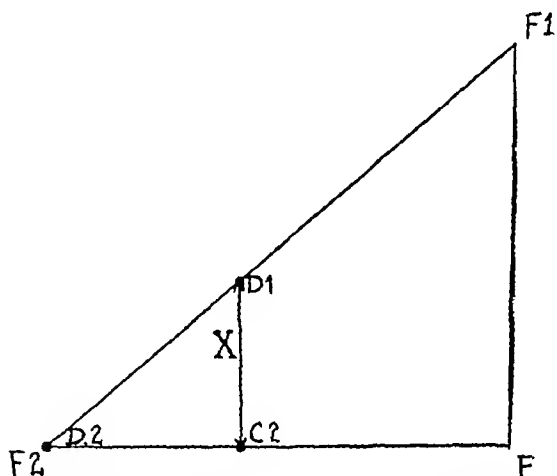


Fig 2 Correction Triangle  $F-F_1-F_2$  is constructed so that  $F-F_2$ , the horizontal arm, is equal to the target-film distance,  $F-F_1$ , the vertical arm, is equal to the target-plane distance

Linear Mensuration may be accomplished by applying distance  $C_2-D_2$  along the horizontal axis, the corrected distance ( $X$ ) is read along the vertical axis

cated From  $D_1$ ,  $D_1-F_1$  is drawn parallel to  $D_2-F_2$  intersecting  $C_2-F_2$  in  $F_1$   $F_1$  represents a second point on the graph By repeating this process of parallel line construction, numerous other points ( $G_1$ ,  $H_1$ ,  $I_1$ , etc.) are located These points are joined by appropriate connecting lines, which represent the true graph of the plane of the inlet

II *Mathematical Proof of the Graphic Method*—(A) *Angular Mensuration* (Fig 3)

1 An arbitrary, more or less central, point in the planeogram,  $C_2$ , is selected

2 From it, radial lines, intersecting the circumference ( $D_2-D_2$ ,  $C_2-E_2$ , etc.) are drawn, thus forming numerous central angles

3 The circumferential points are connected ( $D_2-E_2$ ,  $F_2-G_2$ , etc.) converting the central angles into triangles

4 Successive planes are passed through the target position,  $F$ , and each of the

# THE PLANEGRAM

ANALYSIS AND PRACTICAL APPLICATION, WITH ESPECIAL REFERENCE TO  
MENSURATION OF THE PELVIC INLET

By JULIUS KAUFMAN, M D , Brooklyn, N Y

IN a previous paper (1), we have shown how it is possible to demonstrate various planeograms from two or more radiographs properly taken. The planeograms represent "images" of planes in space parallel to the plane of the x-ray plate, not the true planes themselves. Still, from any planeogram, angular mensuration may be made directly without corrective procedure. For linear mensuration, however, a corrective procedure becomes necessary. The corrective procedure is easily and rapidly accomplished, so that, for example, it is possible to determine the measurements of the axes of the plane of the pelvic inlet in about two minutes, and to reconstruct the true plane in its entirety in about five

Since there are present natural structural planes, such as (1) the plane of the pelvic inlet, (2) the median sagittal plane of the skull, etc., and since these planes are at times readily identifiable in an ordinary single radiograph, the ordinary single radiograph suffices in these instances, thus obviating planeographic determination by multiple exposures.

For clarity's sake, we have divided this treatise into four major sections. I. The application of a graphic method of linear and angular determinations from the planeogram. II. Mathematical proof of the graphic method. III. Further considerations. IV. Summary.

I. *The Application of a Graphic Method of Linear and Angular Determinations from the Planeogram*. **Plane Reconstruction**—In the following we will demonstrate how linear and angular determinations of the plane of the pelvic inlet may be made from its planeogram, and also how the true plane may be reconstructed in its entirety. The method we employ is a general one, of

universal application, but we have applied it specifically to the pelvic inlet since this structure lends itself ideally for demonstration purposes.

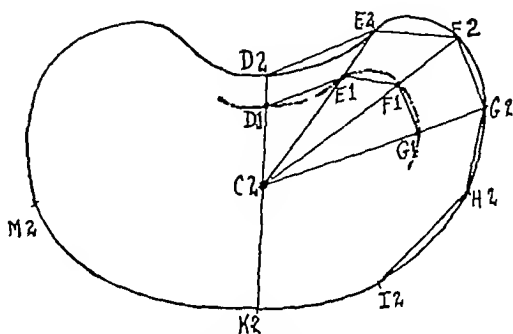


Fig 1 (A) Planeogram. Any angle, D2-C2-E2, in the planeogram is identical with the homologous angle in the plane of the pelvic inlet.

(B) Radial Plane Reconstruction. Any arbitrary, more or less central point in the planeogram C2, is selected. Numerous radii C2-D2, C2-E2, etc., are drawn. Each of the radii is corrected in the correction triangle and re applied along the radius in question, locating several points in the true graph. These located points are connected by appropriate lines.

(C) Perimetric Plane Reconstruction. Numerous radii are drawn from C2. Point D1 is located as before. Line D1-E1 is drawn parallel to D2-E2 locating E1. This process is repeated locating in succession F1, G1, etc. The located points D1, E1, F1, etc. are connected by appropriate lines.

Two points are marked on the patient's skin, the first, anteriorly, corresponding to the upper margin of the symphysis pubis, and the second, posteriorly, corresponding to the tip of the spinous process of the fourth lumbar vertebra. These two points define the plane of the pelvic inlet (2).

The patient is placed upon the x-ray table, in a semirecumbent position, so that the plane of the pelvic inlet as defined by the skin points is horizontal. The central ray falls upon a point 5 cm posterior to the symphysis pubis, but this is not essen-

wishes to locate the anterior wall of the sphenoid sinus, a lateral film of the skull may be made showing two lead markers strapped to the patient's skin at points which lie in the same horizontal plane as the sphenoid. The roentgenogram then shows the anterior wall and the two skin markers. Furthermore, the images of these three structures in the roentgenogram constitute a planeogram so that angular measurements between these three points are true angles, but the distances, since they are distorted, would have to be corrected by the intervention of the correction triangle (3).

In analyzing planeograms one is struck by the startling fact that all planeograms of any one plane are identical for all exposures, regardless of the target position, provided the target-film and target-plane distances are constant. For example, in lateral roentgenograms of the skull, the images of the median sagittal plane (planeogram) are identical, regardless of the position of the target, whether the target, in one case, be directly above the sella turcica or, in the other case, it be removed to a point ten feet below, providing, of course, that the target-film and target-plane distances are constant. This is a simple fact worthy of note and readily provable.

IV *Summary*—In the above, we have analyzed the relationships of points which lie in planes, parallel to the plane of the film, from their images, as represented on

the radiographic film (planeogram). By our analytic method we have shown

(1) Angular measurements, read directly on the planeogram, are true measurements.

(2) Linear measurements may be read from the planeogram by the intervention of the correction triangle.

(3) Natural anatomic planes, planeographically determined planes, and artificially created planes lend themselves to planeographic analysis.

In addition, we have called attention to the interesting fact that all planeograms of an individual plane are identical under certain conditions.

The advantages of planeographic determinations follow.

(1) No instrumentation of any kind is required.

(2) For natural and artificially created planes, the usual single radiograph suffices.

(3) These determinations are simple and rapid, so that the axes of the pelvic inlet, for example, may be measured in about two minutes, and the entire inlet reconstructed in about five.

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lines constructed in the planeogram (for example, F-C 2-D 2)

5 These planes intersect the plane of the pelvic inlet in lines homologous to those

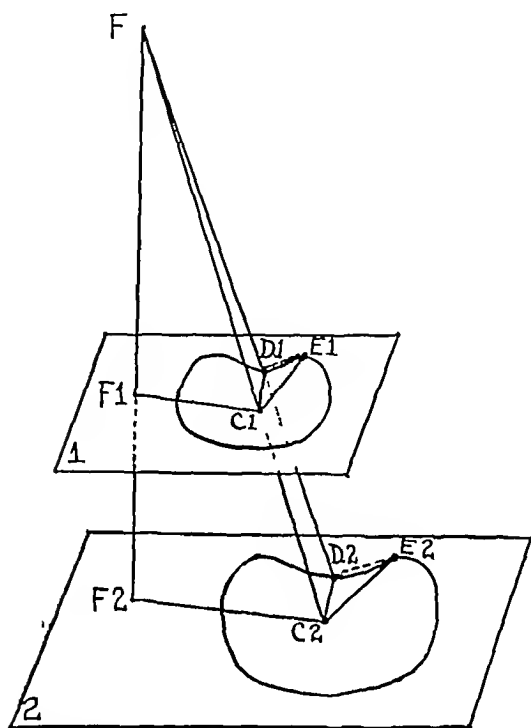


Fig 3 Space Relationships

- (1)  $\frac{C1-D1}{C2-D2} = \frac{F-C1}{F-C2}$
- (2)  $\frac{F-C1}{F-C2} = \frac{F-F1}{F-F2}$
- (3)  $\frac{C1-D1}{C2-D2} = \frac{F-F1}{F-F2}$

in the planeogram (C 2-D 2 and C 1-D 1 are homologous), thus converting the inlet into triangles which are similar to the homologous triangles in the planeogram. Thus follows from the fact that homologous lines in the pelvic inlet are parallel to those in the planeogram (C 2-D 2, for example, is parallel to C 1-D 1)

6 Homologous angles in the inlet, therefore, are equal to those in the planeogram. This establishes the fact that angles measured in the planeogram are true angles, suffer no distortion, and need no corrective procedure

(B) Linear Mensuration "the Correc-

tion Triangle" The construction of the correction triangle has been described above (Fig 2). If we designate C 2-D 1, the corrected distance, by the symbol "X,"

$$\text{then (1) } \frac{X}{C2-D2} = \frac{F-F1}{F-F2},$$

(2) But (Equation 3, Fig 3)

$$\frac{C1-D1}{C2-D2} = \frac{F-F1}{F-F2},$$

$$(3) X = C1-D1$$

(C) Reconstruction —The radial or perimetric methods of reconstruction follow as a natural sequence to the above. Mathematical proof is simple but has been omitted

III *Further Considerations* —In the above we have shown how the planeogram of a natural anatomic plane, such as the pelvic inlet, may be analyzed. We have demonstrated how angular measurements may be made directly from the planeogram, how true linear measurements may be made therefrom by the intervention of the correction triangle, and, finally, how the anatomic true plane may be reconstructed. The requisites for the above are that the anatomic plane be identifiable on the radiograph and that its position be known. For other planes these requisites can be met by planeography using multiple exposures, since by planeography the planeogram is determinable, and, furthermore, this method establishes the position of the plane in question. Suppose, for example, one wishes to determine the measurements of the pelvic canal at the level of the sacro-coccygeal joint. The planeogram is determined for this level by our previous method of multiple exposures. At the same time, this method defines the position of the plane in question with reference to the plane of the plate, so that the process applied above to the pelvic inlet may now be applied to the plane through the points in question.

In other instances it is possible to artificially create planes where none exist naturally. If, for example, a surgeon

Cortical thinning occurs. The medulla is then invaded, where extension is rapid. Soft tissue invasion follows through cortex which has been eroded or pathologically fractured. Embolic phenomena may occur. Periosteal reaction is *nil*. Suppuration is rare, when it is seen it is in advanced cases or post-operatively.

The bones most commonly involved are the humerus, femur, the vertebræ, tibia, and pelvis. A latent period is an outstanding feature of all cases. The passing of a year or more between the time of any known contact or trauma and of the appearance of actual clinical symptoms is almost pathognomonic. Pain is rare in uncomplicated cases. The patient's first complaint is of a painless swelling which slowly increases in size over a period of months or years. The overlying skin is normal. No inflammatory reaction is present. A second way for the disease to manifest itself clinically is a spontaneous fracture with subsequent non-union.

Diagnostic procedures include the intradermal Casom reaction and the complement deviation method which are positive in from 90 to 95 per cent of cases. The precipitin test may also be employed. The best antigen is cyst fluid obtained from sheep and preserved in 0.5 per cent phenol. Diagnostic puncture is done in Australia and South America, but is dangerous because the leakage of cyst fluid may induce anaphylactic shock or spread the disease into the soft tissues. Identification of the fluid depends on the detection of scolices, hooklets, or particles of cyst wall which have a characteristic lamination. Eosinophilia is not a constant finding (13), occurring in only 50 per cent of cases.

Even in Australia, where hydatid disease is common, mistakes in radiologic diagnosis occur (12). It may then be pardonable that in the cases reported in this country no pre-operative x-ray diagnosis was made. The affected bone contains an irregular central rarefied area with thinned and sometimes elevated cortex.

In late cases the entire length of the bone may be involved. No circumferential limiting sclerotic ring is present. The entire rarefied area may be laced with connecting bone trabeculæ, such as are seen in giant-cell tumors. The marked radiologic feature is the absolute lack of any periosteal proliferation. Localized osteitis fibrosa cystica is a difficult differential, although the determination of blood calcium, phosphorus, and phosphatase as well as of other parathyroid pathologic factors will aid. Too, in osteitis fibrosa cystica the trabeculæ are sharper and bowing deformities are present. Giant-cell tumor, simple bone cysts, osteolytic bone sarcoma and malignant metastases have to be ruled out. Syphilitic and acid-fast bone infections are also to be considered. An osteomyelitis may be differentiated by its bone-productive changes, although it may be secondarily engrafted upon an echinococcus lesion. In vertebral involvement tuberculosis is to be considered. Pott's disease shows atrophy, while echinococcus disease does not.

Prognosis is poor, considering the factors of inevitable non-union in cases of fracture, the rapidity of soft tissue extension, and joint involvement. Pessano (2) reports a mortality of 84.6 per cent in the cases he collected. Therapy is radical. In countries where the disease is endemic, surgery is employed as soon as a diagnosis is made. A complete excision of the bone is done and an autogenous bone graft placed *in situ*. In cases in which extensive soft tissue infection has occurred, amputation or even disarticulation is done. In other words, radical treatment is necessary at an early date. As an adjuvant, the intravenous administration of arsenicals has been tried (2, 14, and 15) and is said to be helpful. Diathermy and deep x-ray therapy have no effect upon the course of the disease (11 and 16). Experimentally, a specific serotherapy has not been successful (17). The use of hydatid antitoxin for active immunization has also been reported (18).

The following is a résumé of the im-

# ECHINOCOCCUS CYST OF THE STERNUM

By SAMUEL E SINBERG, M D, *New York City*

**E**CHINOCOCCUS cysts of bone are rarities the world over. Even in countries like Australia, South America, and southern Europe where echinococcus disease is common, bone involvement is limited to about 1 per cent of all cases. Greenway (1) tabulated during the years from 1910 to 1921, 2,470 cases of echinococcus disease in Argentina, among which only nine were in bone. Pessano (2), in a careful analysis of cases in Argentina, found only 28 bone cases up to 1933, including the two he was publishing. Toole (3) found only nine cases of bone involvement in the 2,827 cases he had collected in Greece for 29 years. In a survey of the world literature in 1913, Bauer (4) was able to find 243 cases involving bone, four of which were in the sternum. In 1930, Pasquali (5) added 406 additional cases to this number, of these, nine involved the sternum and ribs. Since 1930 we have been able to find four additional cases in bone (6).

In North America where hydatid disease is rare, a similar ratio prevails. Up to 1902, Lyon (7) collected 241 cases of echinococcus disease in North America, only one of which involved bone. In 1917, Walker and Cummins (8) described a case of tibial involvement. In 1926, Hines (9) reported a case of spinal and renal involvement producing a compression myelitis, in 1930, Stone (10) reported a case of sacral and iliac involvement, and in 1932, B. L. Coley (11) reported two cases involving the pelvis. The case which forms the topic of this paper will, therefore, be the seventh report of bone echinococcus and the only one of the sternum in North America. It is interesting to note that all of these cases occurred in natives of foreign countries with the exception of Lyon's patient, who was enlisted in the Navy and had spent much time abroad.

It will be recalled that the mature *Tænia echinococcus* inhabits the intestines of the

dog and wolf. The hydatid form of the disease is present in cattle, sheep, and in man. The adult worm, 25 to 50 mm long, consists of four segments containing many ova. When these reach man's digestive tract the embryos are set free by the digestive juices, work their way into the intestinal coats, and are then distributed by the portal circulation to the rest of the body, 70 per cent of cases occur in the liver, 10 per cent are filtered out by the lungs, and 20 per cent occur in other organs (spleen, brain, heart, bone). Dévé, who has had extensive clinical and laboratory experience, maintains that the lymphatics also play a part in spreading the disease.

The age period usually affected is between 20 and 40 (63 per cent). The disease is rare in childhood, perhaps because of the long latent period between infestation and clinical manifestation. The ratio of males to females is 57 to 43. The exact relation of trauma as a causative factor is undecided. Pessano (2) and Dew (12) believe it may have an important bearing but no definite casual relationship has ever been proven. In the case to be reported a history of trauma was elicited.

Although most embryos lodge in the liver and lung, a few reach the arterial circulation, through the lung capillaries or perhaps through the patent foramen ovale. Because of their vascularity, the epiphyseal ends of the long bones are usually the primary site of osseous invasion, where it arouses a cellular reaction of leukocytes, eosinophiles, and giant cells. The usual diverticulated form of the cysts seen in bone, sometimes with very little fluid, as opposed to the uniform, rounded cysts seen in soft tissues, is due to the resistant nature of the bony structure. Pressure thins the bone and widens the Haversian canals. As the process develops, the arteries may be occluded, leading to bone necrosis and sequestration.

Cortical thinning occurs. The medulla is then invaded, where extension is rapid. Soft tissue invasion follows through cortex which has been eroded or pathologically fractured. Embolic phenomena may occur. Periosteal reaction is *nil*. Suppuration is rare, when it is seen it is in advanced cases or post-operatively.

The bones most commonly involved are the humerus, femur, the vertebrae, tibia, and pelvis. A latent period is an outstanding feature of all cases. The passing of a year or more between the time of any known contact or trauma and of the appearance of actual clinical symptoms is almost pathognomonic. Pain is rare in uncomplicated cases. The patient's first complaint is of a painless swelling which slowly increases in size over a period of months or years. The overlying skin is normal. No inflammatory reaction is present. A second way for the disease to manifest itself clinically is a spontaneous fracture with subsequent non-union.

Diagnostic procedures include the intradermal Casoni reaction and the complement deviation method which are positive in from 90 to 95 per cent of cases. The precipitin test may also be employed. The best antigen is cyst fluid obtained from sheep and preserved in 0.5 per cent phenol. Diagnostic puncture is done in Australia and South America, but is dangerous because the leakage of cyst fluid may induce anaphylactic shock or spread the disease into the soft tissues. Identification of the fluid depends on the detection of scolices, hooklets, or particles of cyst wall which have a characteristic lamination. Eosinophilia is not a constant finding (13), occurring in only 50 per cent of cases.

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The following is a résumé of the im-





Fig 1



Fig 2

portant points in the case to be reported of echinococcus cyst of the sternum

V C, male, aged 15 years, was born in Italy, and has been in the United States for six years. He was sent to the West Side Hospital, New York City, by Dr R J Ferrara and Dr Carl J Lowe, where he was admitted on July 11, 1933.

*Chief Complaint*—Swelling in the upper anterior chest associated with pain.

*History*—About one and a half years previously, a playmate accidentally fell on the patient's anterior chest. A few weeks later the latter noticed a slight swelling over the upper anterior chest wall. He experienced no pain at that time. The swelling gradually increased in size and became softer. Not until three weeks prior to admission did the patient begin complaining of a dull ache in the region of the tumor, which was fairly constant and non-radiating. The family physician advised hospitalization.

There was no history of previous severe illnesses. Two years prior to admission, the patient had been in an automobile accident and was unconscious for ten minutes, having injured his neck and right shoulder. His personal habits were nega-

tive. Until six years ago, the boy lived in Italy on a farm where he was in contact with sheep and dogs.

*Physical Examination*—The entire physical examination was negative with the exception of the local condition. In the second left intercostal space at the sternal border and over the left side of the sternum there was a swelling about the size of a plum, not tender, immovable. This mass was cystic, slightly crepitant, and had a rubbery, spongy consistency. No pulsations or inflammatory or pressure signs were present. The skin over the mass was normal.

*Laboratory Examinations*—The patient's blood count, taken on July 12, 1933, revealed the following: red cells, 4,600,000, hemoglobin, 80 per cent, white cells, 8,000, polymorphonuclears, 73 per cent, lymphocytes, 24 per cent, transitionals, 2 per cent, large mononuclears, 1 per cent. Urine was negative, Wassermann was negative. On July 19, 1933, his blood count was as follows: red cells, 4,500,000, hemoglobin, 70 per cent, white cells 14,600, polymorphonuclears, 71 per cent, lymphocytes, 15 per cent, large mononuclears, 8 per cent, myelocytes, 5 per cent,

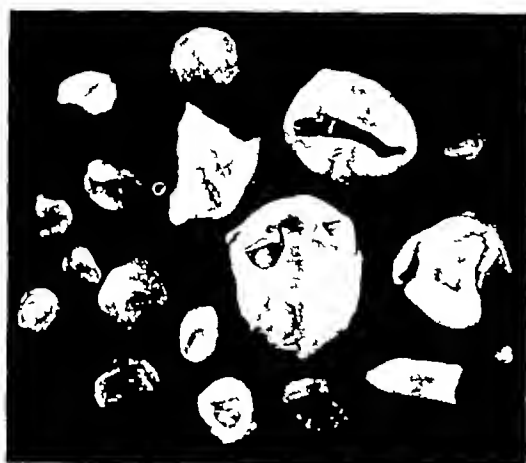


Fig 3

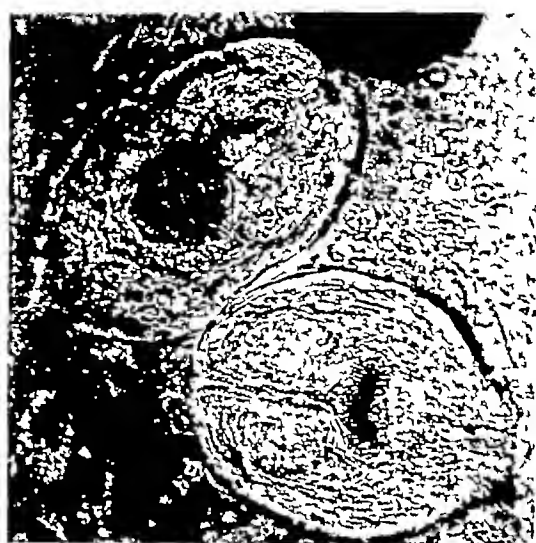


Fig 4

eosinophiles, 1 per cent Albumin 1 plus and a rare granular cast were found in the urine (slight superficial wound infection)

X-ray examination (Figs 1 and 2) revealed a rarefied, expansile swelling of the upper left aspect of the manubrium. The cortex was thinned but not perforated. No periosteal proliferation was present. Numerous trabeculae traversed the rarefied area. A pre-operative diagnosis of giant-cell tumor or simple bone cyst was made. Dr. Lowe, the attending physician on the case, suggested the possibility of echinococcus cyst. A biopsy was decided upon.

**Operation**—The patient was operated upon July 12, 1933, by Dr. Lowe. A transverse incision 6 cm. in length was made over the left border of the manubrium to the third rib. The subcutaneous and deep fascia as well as fibers of the pectoralis major were separated. A grayish fluctuating mass was brought to view. Puncture with a syringe and large gaged needles revealed no fluid. The sternum was denuded of periosteum with an elevator, and part of the manubrium was removed with a bone forceps. On attempting to separate the cyst wall from the bone near the mid-line, the wall ruptured and masses of larger and smaller cysts protruded. The main cyst was washed out with saline solution, the cavity holding from 55 to 60 c.c., and all visible cysts removed. A probe was passed to the base of the neck.

A rubber tube drain gauze packing was placed *in situ*.

**Macroscopic Examination**—The specimen consisted of numerous cysts of different sizes, from that of a small grape to that of a small plum, varying in diameter from 0.3 to 3.0 cm. (Fig. 3). Their walls were translucent and the inner surfaces had a white amber, gelatinous material adhering to them. Some of the cysts were collapsed.

**Microscopic Examination**—Stained sections from the wall of the cyst showed a characteristic lamination which was characteristic of an echinococcus cyst. The fluid from some of the uncollapsed cysts was centrifuged and scolices were found, characteristic of echinococcus cysts (Fig. 4).

Except for a slight superficial infection, the patient made an uneventful recovery and was discharged from the hospital on July 30. At the time of discharge the cyst cavity held 20 cubic centimeters. At the present writing, the cavity has been completely obliterated.

#### SUMMARY

A case of echinococcus cyst of the sternum is reported. The world literature on the subject is tabulated and a brief résumé is given of the rarity of bone echinococcus involvement, of the life his-

tory of this tape worm, etiologic factors, pathogenesis, diagnosis, prognosis, and treatment

We wish to express our appreciation to the Department of Pathology of the Hospital for Joint Diseases for their aid in this case

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# PNEUMOTHORAX TREATMENT OF TUBERCULOSIS<sup>1</sup>

A CLINICAL AND ROENTGENOLOGICAL EVALUATION

By ROSS K. CHILDERHOSE, M.D., Associate Physician, Devitts' Camp, Allenwood, Pennsylvania

THE successful practice of artificial pneumothorax in pulmonary tuberculosis requires the complete co-operation of the clinician and the roentgenologist. So necessary is this that it is impossible to carry the treatment to a successful conclusion without careful roentgenologic studies throughout the long period required for pneumothorax therapy. With this in mind, it behooves us as roentgenologists to have a thorough knowledge of the various phases in the treatment so as to assist accurately the clinician in the handling of the various problems that constantly arise under collapse therapy. While pneumothorax treatment has been in general use in sanatoria for the past twenty years, yet it is only recently that its use has spread to the clinic and the private office. Because of this widespread utilization, we are bound to come more and more in contact with this type of therapy.

The *basic principle* in the treatment of pulmonary tuberculosis is *rest*. Pneumothorax is essentially the application of rest in the localized manner to the affected area of the lung, and thus it enhances the already accepted value of generalized rest. This localized rest to the lung under artificial pneumothorax is the result of a collapse of the lung, and not compression. Modern technic calls for a maintenance of an intrapleural pressure that is slightly less than atmospheric pressure at any time during quiet respiration, and may therefore be termed "collapse therapy."

The effects of this collapse are many, and the clinical improvement in many cases is astounding. From a mechanical point of view there are two distinct results. First, it permits the normal tendency of pulmonary elastic and connective tissues to con-



Fig 1 Pneumothorax, right side, in the upright position. Note air covering the upper lobe and lower lobe spread out over the diaphragm.

tract and shrink, and second, if the collapse is sufficiently great, it will bring in apposition cavity walls, and thus facilitate the healing and obliteration of these excavations.

*Physiologically*, the contracted lung shows a certain degree of passive hyperemia with a relative ischemia, and accompanying this is a distinct impedance of the lymphatic drainage. A combination of all these factors results in a marked decrease in the absorption of tuberculous toxins and a tendency to proliferation of connective tissue. The closure of cavities with consequent decrease in expectoration and eventual elimination of positive sputum relieves the patient of the constant danger of further bronchiogenic spread.

It is not within the scope of this paper to discuss the technic of insufflation, but it is interesting to note that, despite the type of

<sup>1</sup> Read before the Annual Meeting of the Pennsylvania Radiological Society, Williamsport, Pa., June 6, 1936.

gas which may be insufflated into the pleural space, it is soon converted by gaseous exchange with the blood to a mix-

cases of pulmonary tuberculosis. In basal tuberculosis, it is obviously of no avail unless one is willing to collapse the entire



Fig 2 Same patient as shown in Figure 1. Lateral position with pneumothorax side up. Note that the lung has extended to the apex of the pleural space and that the air overlies the lateral wall of the lung.

ture consisting of 4 per cent oxygen, 6 per cent carbon dioxide, and 90 per cent nitrogen (1). I have used oxygen, nitrogen, and air at different times in pneumothorax treatments, and have come to the conclusion that there is no advantage in using any other gas but air. When air is first insufflated into the pleural space it tends to rise to the top, and many unique explanations have been given to account for it, but the most logical discussion is that by Korol (2), who believes that the lungs sink by reason of gravity, and permits the air to collect over the apex of the lung (Figs 1, 2, and 3). Since tuberculosis has a predilection for the upper lobe, this fortunate coincidence of apical localization of air makes the treatment appropriate in nearly all

lung. The degree of collapse is greatest in the outer-two-thirds of the lung, while the inner one-third, which is largely supported by the larger bronchi, resists this collapsing action, and centrally located cavities are sometimes difficult to collapse.

The indication for pneumothorax are few but important. It is the consensus of opinion that any spreading unilateral lesion with positive sputum requires collapse. All cavities require obliteration either by pneumothorax or some type of surgical collapse. Some men go so far as to say that a sputum which is positive for tubercle bacilli indicates a cavity, whether or not it can be demonstrated on the roentgenogram. Certainly a positive sputum means an open ulceration in the lung and is a very



Fig 3

Fig 3 Same patient as shown in Figures 1 and 2, 'knee-chest' position. Observe how the air now covers the lower lobe, and that the lung has 'sunk' to the apex of the pleural space. These three films illustrate the shifting of the lung by the action of gravity.

Fig 4

Fig 4 Pneumothorax, right side, position upright, taken in maximum inspiration. Little evidence of any pleural adhesions or pleural fluid.

serious menace, not only to those who associate with the patient, but to the patient himself. He is in constant danger of a bronchiogenic spread, and therefore, the basic requirement in the treatment of tuberculosis is to eliminate this hazard. Pneumothorax treatment does this most effectively, it is also the most successful form of treatment of hemoptysis. Pleural effusions of tuberculous etiology should be aspirated and converted into a therapeutic pneumothorax so as to heal the lesion. Unfortunately, this is not a generally accepted fact, and I have seen many cases of advanced tuberculosis the history of which shows a pleural effusion in the past which has either been aspirated and had no air replacement or the fluid has been allowed to absorb naturally. These unfortunate patients have developed adherent pleurae so that now pneumothorax is impossible because of the dense pleural adhesions. The same principle applies to the spon-

taneous pneumothorax, it should be maintained under slightly negative pressure as a therapeutic pneumothorax until the lesion is perfectly healed.

There are two schools of thought in respect to the degree of collapse necessary to secure optimum results. One group, headed by Barlow and his associates (3), have advocated the so-called "selective collapse" in which only the diseased portion was permitted to retract and the remainder of the lung allowed the fullest expansion. This method has one advantage in that, after completion of the treatment the lung is easily re-expanded. There is, too, less pressure on the mediastinum and herniation is rarely seen with this method. On the other hand, there are several disadvantages which, in my opinion, far outweigh the advantages, so that I favor a more complete collapse, such as can be obtained by a slightly negative intrapleural pressure on quiet respiration. The most



Fig 5 Same patient as shown in Figure 4. Film taken in maximum expiration a few minutes after Figure 4. Note pleural adhesions extending to second interspace and pleural fluid. This film illustrates the value of expiration views in pneumothorax therapy.

important of these disadvantages of the "selective collapse" is the tendency to form pleural adhesions in cases in which the lung is in contact with the chest wall. One should be always on the watch for such, and they can be detected only by roentgenograms or by fluoroscopy. Such adhesions tend to contract in the course of time, and thus re-expand the lung by an obliterating pleuritis, when this occurs the pneumothorax will cease to exist. It has been my practice to guard against this by numerous fluoroscopic and film studies, and thus be certain that the lung is nowhere in contact with the thoracic wall during the entire period of treatment.

Burrell's experience has been similar, and he is of the opinion that final results are definitely better when a large proportion of the lung has been collapsed (4). Progress of the disease to the contralateral lung may be expected three times as often in those cases in which the collapse is partial, such as those due to adhesions, than in

the patients in whom the lung collapse is complete.

The complications that may arise in the course of treatment can be recognized only by the roentgenogram or by fluoroscopy. The clinician is more dependent on the roentgenologist in this way than is the surgeon in the treatment of fractures. The two outstanding complications are those of pleural adhesions and the formation of pleural fluid. Most adhesions may be recognized in the standard stereoscopic films taken in maximum inspiration. However, it has been my experience that greater information may be obtained in two single exposures, one taken in maximum inspiration and the other in minimum inspiration (Figs 4 and 5). In this way many adhesions are brought to view that might not otherwise be seen. In addition, one may judge to some extent whether pulmonary tissue is present in the adhesion and thus give valuable advice to the surgeon contemplating internal pneumolysis. Ornstein, of New York, advises the use of the lordotic position to demonstrate pleural adhesions that may be in the region of the apex. I have found this technic most satisfactory. On several occasions the technic of Haight and Peirce (5) in which oblique stereoscopic films are taken has been of value in accurately locating the adhesions. Such special technic pictures are advisable only in cases in which a detailed study is required and are not necessary as a routine procedure.

It is the duty of the roentgenologist, after he has located and studied any pleural adhesions, to report their exact location and to state whether, in his opinion, they are likely to prevent a satisfactory collapse of the lung. Comparisons should be made to previous roentgenograms to determine if the adhesions are stretching. Pleural adhesions present a complication in 40 per cent of pneumothorax cases (6), and the cutting of these adhesions by the electric current under thoracoscopic control is one of the greatest advances in phthisiotherapy. By severing these adhesions the required degree of collapse can be secured and the

cavities which have resisted closure may now have their walls in apposition and their healing accelerated. The operation requires specialized training, the mortality is *nil* and the results are gratifying. Drash and Nicholls (7) report a satisfactory clinical collapse after operation in over 90 per cent of these patients. Following such operations it is necessary to examine the patient daily for the formation of any pleural fluid, and to determine the extent of the collapse. For a short time following the operation, we have found that the air is often lost in a rapid manner, and refills of air must be given at shorter intervals. Lack of appreciation of these points will sometimes ruin the results of a perfectly performed operation.

The formation of a pleural effusion occurs to some extent in most pneumothorax patients at some time or other. The amount of fluid varies from a mere trace to massive quantities. About 20 per cent of our patients have sufficient quantity to require attention. All patients who develop fluid that rises to one-half inch above the dome of the diaphragm are aspirated and the fluid replaced with air. In this way the pleural cavity is kept relatively dry and the position of the lung is at all times under observation. If the opposite procedure, *i. e.*, to allow the fluid to accumulate until it gave symptoms and signs such as increased pulse and embarrassed respiration, is followed, the results are frequently unfortunate in that the lung will "creep" out under the fluid to the chest wall, adhere, and an obliterating pleuritis will result. The dense shadow cast by the fluid prevents an accurate localization of the lung outline. Such dangers may be readily avoided by frequent aspiration and close observation under the fluoroscope and film. These repeated aspirations are never attended by a secondary infection if ordinary care is observed. These effusions have been attributed to the presence of tubercles on the pleura (and certainly effusions form more often in advanced cases), or to the tearing of small adhesions in the process of collapse.

Careful roentgenologic control and supervision will also detect any spread of the disease to the contralateral lung. This complication must be detected at the earliest possible moment and it cannot be done by physical signs and symptoms (8). We no longer depend upon the stethoscope for an accurate estimation of any extension of the disease, and the full responsibility for this early detection falls on the roentgenologist. Mediastinal hernia is readily seen by the fluoroscope in the patient during full expiration. The use of the roentgenogram taken in maximum expiration will demonstrate any weakness of the mediastinum. A moderate shifting of the mediastinum is commonly found and should cause no undue alarm. However, there are a few patients in whom a marked bulging of herniation may occur at either of the two "weak" spots of the mediastinum. These areas are located first behind the sternum between the first and third ribs, and the second is posteriorly between the heart and the spinal column in the posterior mediastinum. Involvement of the upper area is the one most commonly seen. These patients with a labile mediastinum sometime present quite a problem in attempting to secure a satisfactory collapse. It is occasionally impossible to apply sufficient intrapleural pressure to close cavities, and our pneumothorax treatment is very disappointing.

There is one more complication which we, as roentgenologists, fortunately do not see, but which the clinician keeps constantly in mind. It is air embolism. Hamilton and Rothstein (9) believe this occurs one in every 500 to 1,000 treatments, while Matson (10) found a "gas embolism-pleural shock complex" 19 times in 20,000 insufflations, two of which were fatal. My own experience has been somewhat more fortunate in that in over 12,000 insufflations I have never observed this complication. A scrupulous observation of a careful technic is the best insurance against such a damage.

*Bilateral collapse* has not been as prominent a subject as that of the standard type unilateral pneumothorax, partly because of





Fig 5 Same patient as shown in Figure 4. Film taken in maximum expiration a few minutes after Figure 4. Note pleural adhesions extending to second interspace and pleural fluid. This film illustrates the value of expiration views in pneumothorax therapy.

important of these disadvantages of the "selective collapse" is the tendency to form pleural adhesions in cases in which the lung is in contact with the chest wall. One should be always on the watch for such, and they can be detected only by roentgenograms or by fluoroscopy. Such adhesions tend to contract in the course of time, and thus re-expand the lung by an obliterating pleuritis, when this occurs the pneumothorax will cease to exist. It has been my practice to guard against this by numerous fluoroscopic and film studies, and thus be certain that the lung is nowhere in contact with the thoracic wall during the entire period of treatment.

Burrell's experience has been similar, and he is of the opinion that final results are definitely better when a large proportion of the lung has been collapsed (4). Progress of the disease to the contralateral lung may be expected three times as often in those cases in which the collapse is partial, such as those due to adhesions, than in

the patients in whom the lung collapse is complete.

The complications that may arise in the course of treatment can be recognized only by the roentgenogram or by fluoroscopy. The clinician is more dependent on the roentgenologist in this way than is the surgeon in the treatment of fractures. The two outstanding complications are those of pleural adhesions and the formation of pleural fluid. Most adhesions may be recognized in the standard stereoscopic films taken in maximum inspiration. However, it has been my experience that greater information may be obtained in two single exposures, one taken in maximum inspiration and the other in minimum inspiration (Figs 4 and 5). In this way many adhesions are brought to view that might not otherwise be seen. In addition, one may judge to some extent whether pulmonary tissue is present in the adhesion and thus give valuable advice to the surgeon contemplating internal pneumolysis. Ornstein, of New York, advises the use of the lordotic position to demonstrate pleural adhesions that may be in the region of the apex. I have found this technic most satisfactory. On several occasions the technic of Haight and Peirce (5) in which oblique stereoscopic films are taken has been of value in accurately locating the adhesions. Such special technic pictures are advisable only in cases in which a detailed study is required and are not necessary as a routine procedure.

It is the duty of the roentgenologist, after he has located and studied any pleural adhesions, to report their exact location and to state whether, in his opinion, they are likely to prevent a satisfactory collapse of the lung. Comparisons should be made to previous roentgenograms to determine if the adhesions are stretching. Pleural adhesions present a complication in 40 per cent of pneumothorax cases (6), and the cutting of these adhesions by the electric current under thoracoscopic control is one of the greatest advances in phthisiotherapy. By severing these adhesions the required degree of collapse can be secured and the

Merely to rid the patient of all evidences of toxemia, to restore his weight and strength to normal, are not enough to effect a cure. In the therapy of tuberculosis there is a great temptation to consider the disease as "arrested" or "apparently cured" soon after he has been restored seemingly to normal health, and nowhere is this deception more accepted than with the patient himself. The most difficult part of this treatment is not in restoring him to well-being, but in convincing him that the treatment of tuberculosis requires *years* and not months.

Because of this it is generally agreed that the collapse should be maintained for a period of not less than three years. Some advocate from five to six years (12). One should always remember that just because the lung is well collapsed, the patient is not necessarily able to work. Unfortunately there has developed in recent years a careless habit among physicians to permit exercise, usually in the form of work, during the period when the disease is still active. This tendency cannot be condemned too strongly. The disease can advance easily in the lung even if the lung be well collapsed, and unless we give the body the generalized rest that is so much required, we are courting grave risks. A good plan is to consider our pneumothorax patients as bed patients for the first six months. This does not necessarily mean a strict bed rest, but they should not be permitted any great exercise. Usually the patient is able to perform part-time work during the second year of treatment and full-time after that. Under collapse the roentgenogram admittedly is of small value in determining the degree of healing, and the amount of exercise may be governed by the blood sedimentation rate.

The *re-expansion of the lung* should be done just as carefully as the collapse. In those patients in whom there has been extensive destruction by cavities, one should remember the danger of attempting to re-expand the lung too quickly. In these cases it is naturally impossible for the lung to completely hypertrophy by a compensa-

tory emphysema and refill the original space. The extensive degree of fibrosis that forms in the long period of collapse precludes such a possible expansion and as a result the mediastinum is drawn well to the affected side. Thus we will see some of the most extreme instances of mediastinal shift. In cases in which the mediastinum has become thickened and stiffened by the presence of a pleural exudate this shift is not noticed to nearly such a degree and, therefore, a high degree of tension is exerted on this fibrosis. Consequently, there is always the possibility of reopening the well-fibrosed lesion. To lessen this danger we have sometimes employed a phrenic neurectomy which by releasing the diaphragm upward will lessen the space to which the lung must re-expand. During the period of re-expansion one sees a tendency for the formation of a moderate pleural effusion, which because of thickened pleura will not absorb and must be aspirated to facilitate the re-expansion of the lung.

These remarks on pneumothorax therapy are intended to give the clinician's viewpoint on the management of these patients and the relationship which is required of the roentgenologist. Numerous occasions will arise in which a thorough knowledge of the treatment will enable the roentgenologist to give valuable advice and suggestions in the handling of these patients, and I thoroughly believe that he is just as much responsible and fully as much entitled to the credit that comes from a successful pneumothorax treatment.

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the greater probability of pleural adhesions interfering with a satisfactory collapse, and partly because of a fear of such complications as spontaneous pneumothorax and pleural effusions. It is just in the past few years that we have attempted the bilateral collapse in all patients in whom we considered it necessary. Thus, in the past year, we have attempted it in six patients, one of whom had no free pleural space because of adhesions, while in another the collapse was insufficient and an attempt was made to increase it by internal pneumolysis. Unfortunately, a spontaneous pneumothorax occurred which was followed by empyema, and the patient died. The remaining four have received marked beneficial results which in a sense may be considered as life-saving, of course, it is too soon to give a final opinion as to their condition. It is remarkable how comfortable and free from dyspnea a patient can be with each upper lobe under collapse. Such patients naturally require the greatest care and observation. Bilateral pneumothorax is impossible without the use of roentgenograms. We fluoroscope these patients before and after every refill of air and take a film every month. It is especially important to make this exposure in expiration so as to determine the maximum degree of collapse obtained.

Bilateral pneumothorax is indicated in the unilateral type of collapse in which a spread of the disease is noted in the contralateral lung. Bilateral collapse should be tried in those patients in whom we see a bilateral active tuberculosis involving each upper lobe, particularly if there is cavity formation. Hemoptysis is an indication if we know that the blood is coming from cavities on each side. Mattill and Kinsella (11), whose experience in this treatment is extensive, found no spontaneous pneumothorax in their series of 90 cases, although a slow leak of air in accidental pneumothorax was seen in 18 but no difficulty was encountered. About 40 per cent of their patients showed successful clinical results and about 25 per cent were partially successful.

Occasionally we have recurrences of the disease in the contralateral lung after a one-sided pneumothorax has been established for two or three years. Sometimes it will occur several years after the pneumothorax has been discontinued, when the patient was apparently cured. Under such circumstances it is necessary to induce a collapse on the new side and if the pneumothorax is in existence on the original side it may have to be abandoned. The induction of this second pneumothorax is known as "alternating pneumothorax," in distinction to the simultaneous pneumothorax on two sides, already discussed. We have three such patients and the results in two have been excellent. One of them has been working for the past year and is in the best of health, the second has had his other pneumothorax for over a year and during this time he has been free from expectoration, fever, and has been of normal weight. His blood sedimentation has been consistently normal. As a precaution he will not be permitted to return to work for another year. The third patient, unfortunately has a slight expectoration which contains tubercle bacilli. She has been fever-free and is at her normal weight, but not able to work.

The routine treatment of these patients necessitates the frequent use of the fluoroscope. All patients should be fluoroscoped once a week, and the frequency of refills judged in this way. Pneumothorax patients should have stereoscopic films made before the induction of the treatment and one month afterward. Films may be taken at intervals of two or three months for the first year of their treatment, during the second and third years of treatment films may be taken every four months unless symptoms should suggest a shorter period. Blood sedimentation estimations done every two months throughout the treatment gives valuable information as to the degree of healing in the collapsed lung.

*Duration of Treatment*—While rest is considered the basis of all treatment of tuberculosis, many physicians lose sight of the fact that time is equally important

in December, 1937, and Dr William J Corcoran, who, with members of his committee, framed the emendation of our Constitution. Especial praise is due to the Local Arrangements Committee who overlooked nothing in making this one of our great meetings

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## COMMUNICATIONS

### NOTES OF CORRECTION

After the November issue was on the press, the paper by Dr E J Bertin, of Philadelphia, entitled "Pneumothorax in the Newborn. Review of Literature and Report of Seven Cases," was added to the Program of the Annual Meeting, at Cincinnati

Dr H Q Woodard, of New York City, desires to say that the title of her paper in the October issue (page 463) should have read "The Effect of Roentgen Rays and Hydrogen Peroxide on Tissue Lipase"

To the EDITOR

In my article, "Mitosis during the Healing of X-ray Burns," RADIOLOGY, August, 1936, 27, 230-232, I have at this late day discovered that, due to my fault, not yours, Table I is headed "No Mitoses per 1,000 Cells," when it should be, as stated five lines above, "No Mitoses per 10,000 Cells." Will you please publish a correction note in a forthcoming issue?

Yours truly,

JOHN A CAMERON

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## IN MEMORIAM

Word has just been received of the passing of Dr Willis F Manges. RADIOLOGY

wishes to express the collective grief of its readers, many of whom were Dr Manges' close friends and sincere admirers. In the next issue it is our desire to publish a more extended tribute to Dr Manges than is possible at this late date

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## BOOK REVIEW

"DIE BIOLOGISCHEN GRUNDLAGEN DER STRAHLENBEHANDLUNG. EIN LEHRBUCH FÜR STUDIERENDE UND ARZTE." By Dr med habil FRIEDRICH ELLINGER, vorm Privatdozent für Strahlenkunde an der Universität Berlin, mit einem Geleitwort von Prof Dr phil WALTER FRIEDRICH, Direktor des Institutes für Strahlenforschung der Universität Berlin. Vol 20 of "Sonderbände zur Strahlentherapie," 255 pages, 78 illustrations. Urban & Schwarzenberg, Berlin, 1935. Price, 13 5 RM.

In this book Ellinger presents roentgen therapy from a pharmacologic approach since both roentgen rays and drugs are used in the treatment of disease. He regards radiation biology as a stepping stone to radiotherapy much as pharmacology is to the practice of medicine. His appeal is, therefore, more to the beginner in roentgen therapy and to the general man than it is to the specialist in radiotherapy. The effects of x-ray on both normal and pathologic tissue—as well as ill effects—are discussed in detail and very well illustrated. The radiologist will find in this book a welcome "refresher." The subject matter as a whole is interesting and important to all medical men, because more and more roentgenology is invading their practice. Ellinger is to be congratulated for bringing out this book, the like of which, in English, is sorely needed.

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## THE KIDNEYS

Rupture of the Kidney Following Pyclography  
Louis H Baretz Jour Am Med Assn, March 21, 1936, 106, 980-983

Three cases of rupture are reported, one in a patient with a calculus in a large pyonephrotic sac, one in a patient with an acute or subacute renal infection, and the third in a patient with a subsiding pelvic infection. Overdistention of the pelvis by pyclographic media will cause intrarenal extravasation, throwing into the venous circulation (pyelovenous backflow) not only the medium but also pus, blood, and, in infected cases, micro-organisms.

The normal capacity of the renal pelvis is from 4 to 6 cubic centimeters. An increase over this amount denotes pyelectasis and injection of the pyclographic medium must proceed with caution. To determine the capacity of the pelvis, aspiration should be a routine procedure. It is particularly necessary to use caution in badly infected kidneys, under such conditions excretory urography is indicated whenever possible.

CHARLES G SUTHERLAND, M B (Tor)

The Prognosis in Renal Carcinoma and the Clinical and Pathologic Data Affecting It  
William F Braasch and Miles Griffin Jour Am Med Assn, April 18 1936, 106, 1343-1346

Malignant tumors of the kidney are subdivided into two groups—those which have their origin in the renal cortex and those which arise from the renal pelvis. Tumors of the renal cortex are of common occurrence. In routine studies of the kidney made at autopsy some form of renal neoplasm is found in approximately 10 per cent of adult subjects. Most of these tumors are small, varying in size from 1 to 2 mm to several centimeters. Their histologic structure is usually described as benign; nevertheless such tumors are potentially malignant. In some, a lack of cellular differentiation is found which makes them actually malignant. Some of these tumors may become quite large and the cells may acquire a malignant character without producing clinical manifestations. The histologic structure of renal neoplasms observed at operation is quite different and with but few exceptions they give definite evidence of malignancy. The prognosis in cases of carcinoma of the renal cortex is largely dependent on the degree of cellular differentiation as suggested by Broders. The average post-operative length of life was found to be distinctly longer in patients with tumors of grades 1 and 2 and only an occasional patient with a Grade 4 tumor was alive five years after nephrectomy. Duration of pre-operative symptoms was much longer in cases of tumors of grades 1 and 2 and the duration diminished as the degree of malignancy increased.

The most common form of cortical neoplasm observed is the adenocarcinoma which is commonly called hypernephroma. Its gross appearance, color, apparently circumscribed localization, and the papillary arrangement of its cells are quite distinctive. Adeno-

carcinomas may further be distinguished by the microscopic appearance of these cytoplasmic cells, which may be clear or granular. The post-operative life of patients whose tumors showed clear cells was distinctly longer than those of granular cell type.

Alveolar carcinomas are frequently observed. The gross appearance of these tumors is quite different, and there is usually more diffuse involvement of the entire kidney. Microscopic examination shows that the character and arrangement of the cells are also different than in adenocarcinoma. The slow growth and mild symptoms which usually characterize hypernephromas are in contrast to the clinical data observed in cases of alveolar carcinoma. The post-operative length of life of patients with hypernephroma averages twice as long.

The degree of fixation is apparently of greater prognostic importance than the size of the tumor. Metastasis occurs most frequently with renal tumors of the higher grades of malignancy and may be present without clinical evidence. Lymphatic extension is of frequent occurrence. Metastasis is found most often in the lungs, rather infrequently in the osseous system.

Calcification of tissues in cases of renal adenocarcinoma is a frequent occurrence and indicates a favorable prognosis.

The excretory urogram will give accurate information in a high percentage of cases and should be used routinely in the study of abdominal tumors.

Although clinical data suggest that suprarenal elements may be included in some hypernephromas to account for the vascular manifestations such as hypertension and telangiectasis, neither clinical analysis of the tumors nor post-operative clinical data corroborate such an assumption.

CHARLES G SUTHERLAND, M B (Tor)

## THE KNEE JOINT

Fractures of the Patella. Results of Total and Partial Excisions of the Patella for Acute Fracture  
William E Blodgett and Robert D Fairchild Jour Am Med Assn, June 20, 1936, 106, 2121-2125

Fractures of the patellar border without displacement, longitudinal fractures, certain stellate fractures and transverse or oblique cracks without displacement of the fragments were treated by a walking iron cast to the mid thigh and immobilized in extension for from six to eight weeks. Compound fractures were treated conservatively until infection had cleared and then sutured or excised.

To obviate the difficulties encountered in the majority of methods used for the open reduction of the patella, the method of subtotal resection of the patella or, when indicated, total excision of the patella was performed. It is imperative that the lateral and medial rents in the knee joint capsule be sutured. The results of the removal of the upper third, upper half, or upper two-thirds of the patella or, in fact, the whole patella with suitable indications, would not be

# ABSTRACTS OF CURRENT LITERATURE

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H W HEFKE M D , of Milwaukee, Wisc	C G SUTHERLAND, M B (Tor ), of Rochester, Minn
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**Nodular Bone Formations in the Lungs** R Janker  
Fortschr a d Geh d Röntgenstrahlen, March, 1936, 53, 260-267

This is a report of two cases of nodular (tuberous) type of bone formation in the lungs, with a review of the literature comprising eight additional cases. In such cases one finds histologically multiple osseous casts of alveoli which are regarded in part as produced by inflammatory conditions, in part as the result of chronic passive congestion. Nearly all of these patients were relatively young individuals (average age well below 35 years of age).

All showed cardiac lesions predominantly of the mitral type. For differential diagnosis one has to consider deposition of lime salts in tuberculous foci, calcifications following war gas poisoning and bronchiolitis obliterans, mycoses, pneumoconiosis, gumma. The etiology remains uncertain.

H A JARRE, M D

## PNEUMOCONIOSIS

**Pathologic Interpretations of Roentgenologic Shadows in Pneumoconiosis** Henry C Sweany  
Jour Am Med Assn, June 6, 1936, 106, 1959-1965

Roentgenology should be ranked first for the most accurate qualitative and quantitative measures of tissue damage in the living patient. The author's classification was based chiefly on the type of pathological change, combined with the causative agent. The principal features depend on the presence or absence of specific fibrosis, the presence of lymphatic occlusion, or the presence of the toxic agent that causes irritation. It is:

I. Coniofibrosis, including (1) silicosis, (2) silico-tuberculosis, (3) asbestosis and the like.

II. Coniolymphstasis, including (1) anthracosis, (2) siderosis and the like.

III. Coniotoxicosis, including (1) protein sensitization, (2) direct irritation and other causes.

IV. Mixed processes, (1) anthracosilicosis, (2) siderosilicosis, (3) anthracosilico tuberculosis and other conditions.

In a series of cases antemortem histories and roentgenograms are correlated with postmortem findings.

CHARLES G SUTHERLAND, M B (Tor)

## THE SPINE

**Arthritic Spurs of the Cervical Spine as a Cause for Difficult Swallowing** Otto Spitzenberger  
Röntgen praxis, March 1936, 8, 159-160

Large arthritic spurs on the anterior aspect of the cervical vertebrae may at times be responsible for some difficulties in swallowing. In both of the cases described, very large spurs protruding for one centimeter anterior to the bodies of the third and fourth cervical vertebrae caused a bulging of the posterior wall of the esophagus and were, in the author's opinion, responsible for a moderate dysphagia. It seems that these out-

growths may cause symptoms, especially in that position (normal epiglottic narrowing of the esophagus).

H W HEFKE, M D

## THE STOMACH

**Gastric Carcinoma and Gastric Polyp** W Hollmann  
Röntgenpraxis, June, 1936, 8, 361-364

Konjetzny has stated that there is a definite relationship between carcinoma and benign polyp, and between benign polyp and gastritis. He, therefore, believes that the primary cause for most gastric cancers is a gastritis. This theory is not accepted by many pathologists. For the roentgenologist it is important to know that adenomatous polyp may degenerate into carcinomas (in 50 to 60 per cent, according to Doering and Wexelmann). The roentgenologic diagnosis of a benign tumor does not indicate medical treatment, but surgery. Two cases are described in which the roentgen diagnosis was benign tumor of the stomach. Both cases showed benign tumors, but also malignant degeneration in parts of them. Such cases ought all to be treated surgically, because beginning malignant degeneration may not be shown roentgenologically.

H W HEFKE, M D

**Effect of Anoxemia on the Emptying Time of the Human Stomach. Influence of High Altitudes** Edward J Van Liere  
Arch Int Med, July 1936, 58, 130-135

Anoxemia affects individuals who travel by airplane and those who vacation at high altitudes, as well as those who are afflicted with blood dyscrasias and pulmonary or circulatory disturbances. In these experiments the anoxemia was created by placing the patients in a cylindrical chamber which was gradually decompressed. At a pressure of 560 mm of mercury, corresponding to 8,000 feet altitude, two of three men showed a definite prolongation of gastric emptying time. The third man proved susceptible at a higher degree of anoxemia. One man was refractory at 515 mm of mercury (10,000 feet) but responded at 460 mm of mercury (14,000 feet). At the latter pressure each subject showed a definite prolongation of the emptying time of the stomach—in no case less than 13.2 per cent of the normal time and in one case 166.9 per cent of normal.

E M SHEBESTA, M D

## THE THYMUS

**The Thymoma and Thymic Hyperplasia in Myasthenia Gravis with Observations on the General Pathology** E H Norris  
Am Jour Cancer, July 1936, 27, 421-433

The author summarizes as follows:

Four cases of myasthenia gravis, with autopsies are reported. In two of these a high degree of hyperplasia of the thymus was observed, the other two showed no gross evidence of thymic involvement. Fifty per cent of the reported autopsied cases of



productive of serious consequences Interrupted sutures are used throughout

Following operation a posterior mold or a cast is applied to immobilize the knee in full extension

If the post-operative course is uneventful passive motion is started on the ninth or tenth day and the patient is gotten out of bed This is followed by passive motion three times daily for five days and then active motion with the patient up and about on crutches Weight bearing is started any time after two weeks following the operation The patient leaves the hospital with a tight flannel bandage about the knee and crutches or cane to steady him rather than to take much of his weight Patients can do light work within from six to eight weeks following operation In the younger group of patients heavy work can be done at the end of three months

CHARLES G SUTHERLAND, M B (Tor)

Dislocations of the Knee Joint, with a Report of a Complete External Lateral Dislocation H Earle Conwell and R H Alldredge Jour Am Med Assn., April 11, 1936, 106, 1252-1256

Dislocations of the knee may be complete or incomplete and may be caused by direct or indirect violence Complete dislocations of the knee joint are extremely rare, incomplete dislocations are more common They are classified according to the relation of the upper end of the tibia to the lower end of the femur The various types are

(1) Anterior (40 per cent), which occur when the knee is in full extension either when direct violence is applied to the anterior lower end of the thigh driving the femur backward or when applied to the posterior upper end of the leg near the knee, driving the tibia forward It may also occur by indirect violence, as when one is standing in a falling elevator

(2) Posterior (20 per cent) occurring while the knee is in flexion through direct violence on the anterior upper end of the leg near the knee It may also occur through indirect violence, as occurs when one is running and steps into a hole the leg being fixed and the weight of the whole body being thrown forward on the knee In all posterior dislocations the posterior crucial ligament is ruptured

(3) Lateral dislocations (20 per cent) are caused by forced adduction of the leg or by twisting of the leg on the thigh It may be caused by direct violence against the external surface of the leg high up, or against the inner side of the thigh low down

(4) Medial dislocations (7 per cent) in which the tibia is displaced medially by forced abduction of the leg or by direct violence against the external surface of the leg, high up or against the inside of the thigh low down

(5) Rotary dislocations are rare They are usually caused by the leg being caught in a rotating wheel and rotated about its long axis There are two types, outward or inward, according to the deviation of the toes

Roentgenograms usually prove the diagnosis In uncomplicated cases, closed reduction should be done if

possible When there is swelling in the popliteal space and an absence of pulsation in the dorsalis pedis and posterior tibial arteries, a ruptured popliteal artery should be suspected and exploration performed Prolonged mobilization (6 to 8 weeks) should be carried out Weight bearing with brace crutches physical therapy, active motion, and hot baths should be continued over a long period of time

Prognosis as to life in uncomplicated cases is good The end functional result varies, but in uncomplicated cases, if early and proper treatment is carried out there should be a painless stable knee with moderate and sometimes full motion

CHARLES G SUTHERLAND M B (Tor)

## THE LIVER

The Roentgenological Diagnosis of Abscess on the Concave Surface of the Liver J M Miles Am Jour Roentgenol and Rad Ther, January, 1936 35, 65-69

Abscess of the left lobe of the liver causes no diaphragmatic change but rather an epigastric tumor pressing on the lesser curvature of the stomach Symptoms vary Temperature and leucocytosis may or may not be present Loss of weight may be considerable

S M ATKINS M D

## THE LUNGS

Branching Bone Formations in the Lungs R Janke Fortschr a d Geb d Röntgenstrahlen June 1936 53, 840-860

This is a report of five cases three of which showed monolateral two bilateral ramifying bone formations in the lungs There is a detailed autopsy report on one case and four exclusively roentgenologic diagnoses based upon rather opaque branchings and network like shadows in the pulmonary tissue Included in this paper is a detailed review of 34 additional cases from the literature

This branching form of bone formation in the lungs appears to be etiologically quite different from the tuberous or nodular form The average age of the patients under consideration here is above 60 years, very few (12.82 per cent) showed cardiac lesions A uniform clinical history could not be elicited Occupational disease had to be ruled out Tuberculosis and bronchiectases were out of the question Various authors assume various etiologic factors like metaplasia following inflammatory processes, congenital malformation of tissue scattered cellular foci, senile processes, and endarteritis obliterans

(In connection with this paper and one by the same author on Nodular Formations in the Lungs (next page) we should refer to a third one on the same subject by H. Salinger, Bone Formation in the Lungs with Particular Attention to the Nodular Form, Fortschr a d Geb d Röntgenstrahlen, September 1932 46, 269-275)

H A JARRE, M.D

# RADIOLOGY

A MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

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myasthenia gravis have shown some form of thymic involvement

Pathologic conditions which have been regarded as benign tumors of the thymus have been found in one-half of the cases of myasthenia gravis in which demonstrable changes in the thymus were recognized. Such cases I have interpreted as conditions of *extreme* epithelial hyperplasia.

Pathologic conditions which have been regarded as instances of enlargement or persistence of the thymus have been found in one-half of the cases of myasthenia gravis in which demonstrable changes in the thymus were recognized. These I have interpreted as conditions of *moderate* epithelial hyperplasia.

HANS A. JARRE, M.D.

## THE THYROID

The Roentgen Therapy of Non-toxic Goiters  
Rudolf Töppner, *Röntgenpraxis*, June 1936, 8, 384-387

Roentgen therapy of benign goiters is usually considered as promising very little. Surgery is the treatment of choice. A few patients are treated because they refuse surgery or because surgery is definitely contra-indicated.

During a period of ten years 71 non-toxic goiters were treated in Holfelder's Institute at Frankfurt, Germany. Of the 71 cases, 41 were non-toxic sub-sternal goiters, others were soft diffuse goiters and others nodular goiters. A hard radiation (180 kv, 0.5 mm Cu) is used. The number of fields depends on the clinical findings. About 1,500 r are given effective in the goiter by two or more fields. The dose is fractionated throughout two weeks. If after three months the desired benefit has not taken place, the same series might be repeated. Undesirable after-effects of roentgen therapy, as myxedema, exophthalmic goiter adhesions, etc. were not observed.

Of the cases with substernal goiter reported one-third was cured, one-half considerably improved. Five cases showed no improvement. The best results were seen in the soft parenchymatous non-toxic goiters next in the substernal goiters, on hard nodular goiters the x-ray treatments had no effect.

H. W. HEFKE, M.D.

## VISCERA (TRANSPOSITION)

Dextrocardia in Children, Henry A. Reisman, *Ann. Int. Med.*, August, 1936, 10, 200-213

The author's summary is as follows:

Eight cases of dextrocardia are reported, three of which were discovered in a series of 11,253 roentgen rays of children's chests. These eight cases were as follows: 1. A true mirror picture dextrocardia with situs inversus. 2. Dextrocardia secondary to congenital eventration of the diaphragm. 3. Acquired dextrocardia secondary to pleuro-pericardial adhesions with non-tuberculous infiltration of the right lung. 4 and 5. Two additional cases of true congenital mirror picture dextrocardia, one of which was associated with a patent interventricular septum, cyanosis and myocardial disease involving the bundle of His. 6. Dextrocardia secondary to congenital diaphragmatic hernia. 7. Dextrocardia secondary to non-tuberculous fibrosis and pleuro-pericardial adhesions in an adult, with autopsy findings. 8. Dextrocardia secondary to empyema on the left side.

A modified classification of dextrocardia is proposed: I. Congenital. 1. True mirror picture dextrocardia (A) with situs inversus, (B) isolated congenital dextrocardia without situs inversus. 2. Dextrocardia due to arrest of development. 3. Congenital dextrocardia with acquired characteristics as that secondary to congenital hernia, eventration or atelectasis. II. Acquired. 1. Dextrocardia developing after birth secondary to acquired conditions.

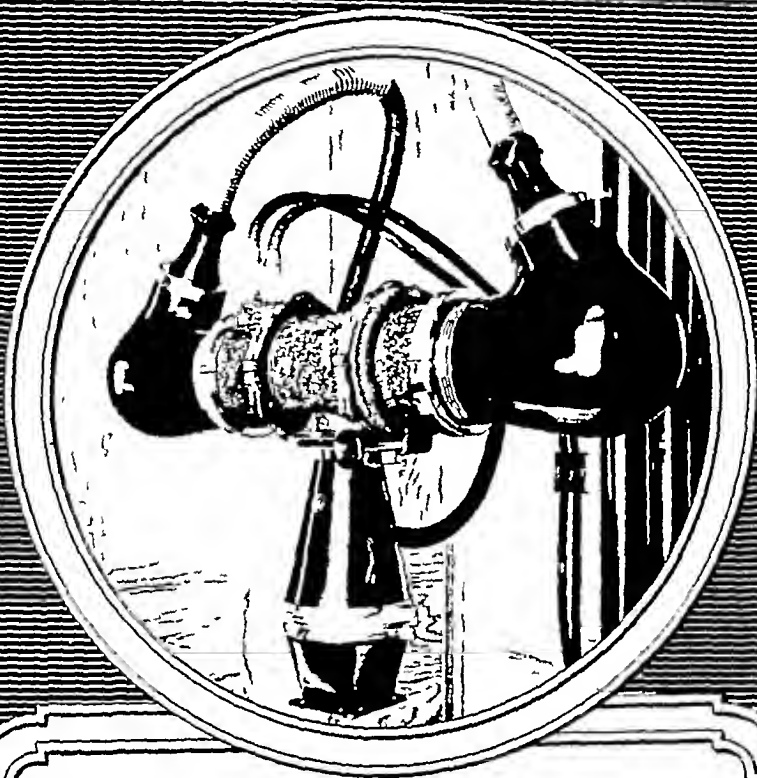
H. A. JARRE, M.D.

# RADIOLOGY

A MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

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## WHY THE USE OF X-RAY IS WORLD-WIDE

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